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The "Springfield Muller" Engine Lathe.

We present on this page an engraving of an 18-inch engine lathe designed by E. A. Muller, of Springfield, Ohio. The general design and proportions of the lathe are plainly shown by the engraving, and as will be seen, conform to modern approved practice. The head-stock is long and heavy, has a five-step cone for a 2½-inch belt, and back gears with a ratio of 12 to 1, the entire 10 spindle speeds being arranged throughout in geometrical progression.

The spindle is forged of hard crucible steel, and has a large, solid collar for face-plates and chucks to screw against, permitting the nose of spindle to be larger in diameter than when it is reduced below the spindle diameter to form a shoulder. The spindle is bored to receive a 1¼-inch round bar in the rough, and the front bearing is of bronze 2¾ inches diameter, 4½ inches long.

The spindle nose is 2¼ inches diameter, 2 inches long, and is threaded, U. S. standard 4 per inch for two-thirds of its length only, thus giving a straight bearing at the back for the face-plate, while the use of the pitch of screw called for by the U. S. standard gives a better wearing thread, and one which will not wedge chucks and face-plates on so tight as where finer pitches are employed.

As will be seen, the feed rod may be driven either by belt or gears, and things are so proportioned that excessively small gears are not used, the driving being from the spindle direct, and the feeds reversed in the apron. By the belt, feeds of 80, 50 and 30 per inch are obtained, while with the gearing, though still using the feed rod, the feeds range from 5 to 105 per inch.

The change from belt to gear feed, or *vice versa*, is made by simply turning the knob, seen in front of the box at the right of the lower feed cone, and no other change, such as removing the belt or disengaging the gears, is required.

The lower feed cone is so arranged that it can be readily adjusted to give any required tension to the feed belt, and this belt may, on this account, be made endless, *i. e.*, without lacings.

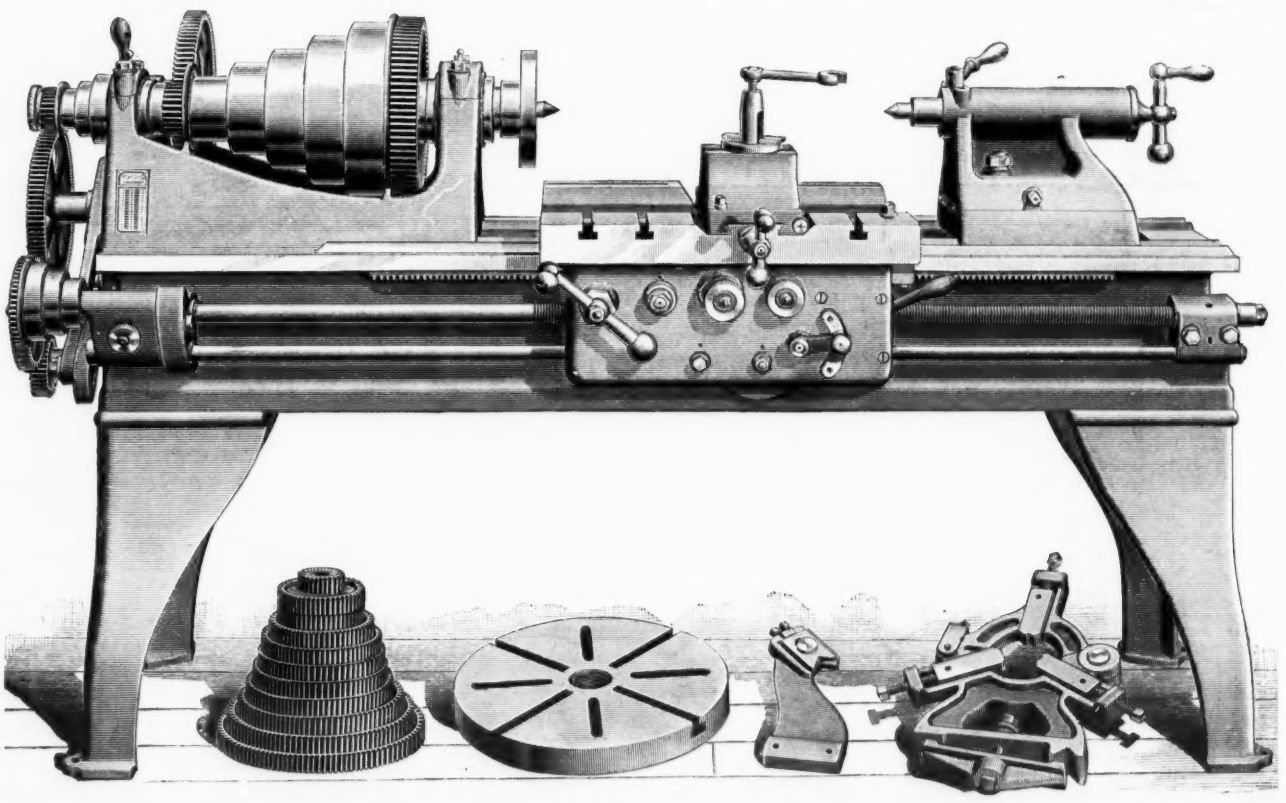
The carriage is 24 inches long, has a bearing upon the bed its full length, and is gibbed outside, front and back. Either a plain or a compound rest is furnished, and when the latter, its crank-handle may be revolved in any position without interfering with cross-feed handle.

The cross-feed is driven positively, *i. e.*, without a friction, and its ratio to the feed-rod is 1 : 4, so that spirals as coarse as 6 per inch can be cut. The rod and the screw-feed cannot be engaged at the same time. An improved taper attachment is supplied when desired, with which tapers up to 4 inches per foot can be turned or bored.

The foot-stock has a 2 inch spindle with 6 inches of movement, and is clamped to the bed by two bolts placed as near the front as possible. There is a countershaft with 12-inch by 4-inch pulleys and friction clutches. Any length of bed is made; with 6-foot bed (taking 2 feet 8 inches between centers), the weight of the lathe is 2,200 pounds.

Nuts, bolt-heads, etc., which are frequently used, are case-hardened; screws, racks, small gears, etc., are made of steel; flat surfaces are scraped to face-plates and cylindrical bearings finished by grinding.

The lathe is made by the Springfield Machine Tool Co, Springfield, Ohio.



THE "SPRINGFIELD-MULLER" ENGINE LATHE.

Calculations for the Flow of Compressed Air and Gas in Pipes, Simplified.

BY WILLIAM COX.

The general formula for the velocity of flow of a fluid in a pipe is

$$V = c\sqrt{\frac{d \times P}{l \times s}},$$

where P is the pressure required to overcome friction in the pipe, and produce the velocity V, s is the density or weight of a cubic foot of the fluid, d and l are the diameter and length of the pipe, while c is a coefficient varying not only with the nature of the fluid and the internal condition of the pipe, but also having very different values for the same fluid, according to different authorities.

In the case of elastic fluids, such as steam and compressed air, under high pressures, another factor requires consideration, namely, the expansion in the pipe of the volume of the fluid, and the influence that this expansion exerts upon the velocity.

The problem of the velocity of flow of water in long pipes has been pretty satisfactorily settled, thanks to the very many careful experiments which have been made, the data thus obtained enabling the various curves of velocity, friction, etc., to be plotted, and therefrom formulæ to be deduced, more or less accurate according to the number and varying conditions of the experiments investigated. In the case, however, of compressed air and gas, such satisfactory and comprehensive data have not been so far obtained as to permit of a reliable and accurate deduction of the exact nature and value of the many factors which have to be taken into account, so that the formulæ in use must be accepted with a certain measure of allowance.

Tables of the friction produced in a limited number of cases by the transmission of compressed air in pipes are given in the catalogues of the makers of compressing machinery. In what follows I therefore assume that the results as given in these are substantially correct, the velocity of flow being supposed to be uniform, my purpose being to show how the loss of pressure for other velocities and corresponding volumes may be easily obtained.

The simplest method is to proceed by means of two simple formulæ, as by such the use of fifth powers and roots is avoided. By the first one we obtain the discharge from a pipe for a known velocity, or the velocity of flow for a known discharge; and by the second one we ascertain the pressure required to overcome friction and produce this velocity.

We have, therefore,

$$D = V \times d^2 \times 0.32725 \qquad (1)$$

and by transposition:

$$V = \frac{D}{d^2 \times 0\ 32725} \qquad (2)$$

$$d = \sqrt{\frac{D}{V \times 0.32725}} \qquad (3)$$

where D = discharge of compressed air in cubic feet per minute;

V = velocity of flow or discharge in feet per second;

d = actual diameter of the pipe in inches.

Table I., which gives the discharge from pipes 1 to 30 inches diameter, for a uniform velocity of one foot per second, simplifies considerably the calculations, as will be seen further on.

Before the velocity of flow of compressed air can be obtained, it is, however, necessary that the contraction of the volume of free air, when subjected to pressure isothermally, be first ascertained. The formula to be used for this is:

$$\left.\begin{matrix}\text{Volume of compressed air}\end{matrix}\right\} = \frac{\text{Volume of free air} \times 15}{\text{Gauge pressure} + 15} \qquad \ldots\ldots\ldots\ldots (4)$$

in which the constant 15 is the approximate atmospheric pressure at sea level; for greater accuracy the constant 14.7 should be used. Thus, suppose 1,000 cubic feet of free air is subjected to a gauge pressure of 60 pounds (pressure above the atmosphere, the absolute pressure being 60 + 15 = 75 pounds), what volume will it occupy?

$$\left.\begin{matrix}\text{Volume of compressed air}\end{matrix}\right\} = \frac{1{,}000 \times 15}{60 + 15} = 200 \text{ cubic feet.}$$

This is the discharge which has to be used in formula (1) in order to obtain the velocity of flow, thus:

A 10 inch pipe, 1,000 feet long, receives 5,367 cubic feet of free air under a gauge pressure of 60 pounds; what will be the velocity of flow? By Eq. (4)

$$\left.\begin{matrix}\text{Volume of compressed air}\end{matrix}\right\} = \frac{5{,}367 \times 15}{60 + 15} = 1{,}073 \text{ cubic feet; then by Table I.}$$

$$\text{Velocity} = \frac{1{,}073}{32.725} = 32.8 \text{ feet per second.}$$

Table II. gives the volume occupied by one cubic foot of free air, when subjected to gauge pressures of 1 to 100 pounds per square inch; also the corresponding weights of one cubic foot of compressed air, the latter being based upon 0.0768 pound for a cubic foot of free air at a temperature of 60° Fahr.

Being now enabled to ascertain the velocity of flow of the compressed air in a given pipe, when the volume of free air em

ployed is known, we come to the question of the pressure required to overcome the friction in the pipe and to produce the velocity. The formula is:

$$F_p = \frac{V^2 \times l \times s}{c \times d}, \qquad (5)$$

which transposed gives

$$V^2 = c\,\frac{F_p \times d}{l \times s}, \qquad (6)$$

$$d = \frac{V^2 \times l \times s}{c \times F_p}. \qquad (7)$$

where F_p = friction pressure in pounds per square inch;
V = velocity of flow of the compressed air in feet per second;
l = length of pipe in feet;
d = diameter of the pipe in inches;
s = density or weight of 1 cubic foot of the compressed air, taken from Table II, and
c = variable coefficient of friction.

In the tables referred to I find that this coefficient is sometimes taken as being 26,267, and in other cases as 27,920. For the sake of simplifying the calculations, and also to give a little safe margin, I have in the following examples adopted 25,000 as the coefficient of friction. Of course, the use of any other figure does not in the least alter the methods of solution. It may, with further knowledge, be found that with compressed air, as with water, the coefficient should vary with the diameter of the pipe or the velocity, or even be a function of both. I may state here in passing that in the case of illuminating gas, opinions are so varied,

TABLE I.

DISCHARGE OF COMPRESSED AIR FROM PIPES IN CUBIC FEET PER MINUTE, WITH VELOCITY = 1 FOOT PER SECOND.

Diam. Ins.	Cubic Feet.	Diam. Ins.	Cubic Feet.	Diam. Ins.	Cubic Feet.
1	0.32725	7	16.035	16	83 776
2	1 3090	8	20.944	18	106 03
3	2.9452	10	32.725	20	130 90
4	5.2360	12	47 124	22	158.39
5	8 1812	14	64.141	24	188.50
6	11.7810	15	73.631	30	294.52

TABLE II.

VOLUMES OF COMPRESSED AIR SUBJECTED TO DIFFERENT GAUGE PRESSURES.

Gauge pressure in pounds per square inch.	Reduced volume of 1 cubic foot of free air.	Weight of 1 cubic foot of compressed air.	Gauge pressure in pounds per square inch.	Reduced volume of 1 cubic foot of free air.	Weight of 1 cubic foot of compressed air.
		Pounds			Pounds
1	0 93750	0 0768	45	0.25000	0.3072
2	0 88235	0.0870	50	0.23077	0.3328
3	0.83333	0.0921	55	0 21428	0.3584
4	0.78947	0.0972	60	0.20000	0.3840
5	0.75000	0.1024	65	0.18750	0.4096
10	0.60000	0 1280	70	0.17647	0.4352
15	0.50000	0 1536	75	0.16667	0 4608
20	0 42857	0.1792	80	0.15789	0 4864
25	0.37500	0.2048	85	0 15000	0 5120
30	0.33333	0.2304	90	0.14385	0 5376
35	0.30000	0.2560	95	0.13636	0 5632
40	0.27273	0.2816	100	0.13043	0.5888

that coefficients varying 45 per cent. between the highest and the lowest are used, showing the great need for further investigation.

Taking now the example already given, let us see what the friction pressure will be.

The velocity was found to be 32.8 feet per second, then $V^2 = 1{,}076$, and from Table II. the value of s for 60 pounds pressure is 0.384, inserting which in Eq. (5) we have

$$\text{Friction pressure} = \frac{1{,}076 \times 1.000 \times 0\ 384}{25{,}000 \times 10} = 1.652$$

pounds per square inch, so that the pressure under which the air would be discharged would be 60 — 1.652 = 58.348 pounds per square inch.

As is the case with all fluids, the friction is proportionately very much greater for small pipes than for large ones. Thus, in this example, its effect is of but small significance; but if the pipe were only half the size, the loss by friction would be very serious.

In the tables referred to, the friction pressure for above is given as 1.573 pounds, the coefficient being 26,267.

The following examples will amply serve to show the methods of applying the formulæ to the solution of a variety of problems connected with the distribution of compressed air:

1 *It is required to discharge from a* 6 *inch pipe* 4,000 *feet long,* 500 *cubic feet of compressed air under a pressure of* 75 *pounds per square inch; what must be the initial gauge pressure?*

By Table I.,

$$V = \frac{500}{11.78} = 42.4, \text{ and } V^2 = 1{,}798.$$

By Table II., $s = 0.4608$.

By Eq. (5),

$$F_p = \frac{1{,}798 \times 4{,}000 \times 0\ 4608}{25{,}000 \times 6} = 22.1$$

pounds per square inch, so that the initial gauge pressure would have to be 75 + 22.1 = 97.1 pounds. As, however, the velocity of flow is excessive, it would be well to increase the diameter of the pipe, thus reducing the friction pressure and the consequent initial gauge pressure.

2. *What diameter of pipe* 5,000 *feet long is required to deliver* 400 *cubic feet of compressed air under a pressure of* 60 *pounds per square inch, and what must be the initial gauge pressure; also what volume of free air will be required? The velocity is not to exceed* 20 *feet per minute.*

By Table I.,

$$\frac{400}{20} = 20 \text{ cubic feet per minute for a velocity of one foot per minute,}$$

therefore an 8 inch pipe should be used.

By Table II., $s = 0.384$.

By Eq. (5),

$$F_p = \frac{400 \times 5\,000 \times 0.384}{25{,}000 \times 8} = 3.84 \text{ pounds,}$$

therefore the initial gauge pressure must be 60 + 3.84 = 63.84 pounds per square inch.

By Table I., the discharge of an 8 inch pipe with a velocity of 20 feet per second = 20.944 × 20 = 419 cubic feet, therefore by Table II. the volume of free air required will be $\frac{419}{0.2}$ = 2,095 cubic feet.

It must, however, be noted that the value of s will in reality be a little more than 0.384, as the initial gauge pressure is found to be 63.84 pounds. If, therefore, very great accuracy is required, a new value of s should be calculated by the formula:

$$\text{Density} = 0.0768 \times \frac{\text{Gauge pressure} + 15}{15},$$

and this new value inserted in Eq. 5 in place of the former one.

3. *It is required to deliver* 200 *cubic feet of compressed air at the end of a pipe* 5,000 *feet long, under a pressure of* 50 *pounds per square inch, the initial pressure not to exceed* 60 *pounds; what diameter of pipe should be used?*

When neither the velocity nor the diameter of the pipe are known, the latter has to be ascertained by trial in the following manner:

By Table II., $s = 0.384$.

Also $F_p = 60 - 50 = 10$ pounds, inserting which in Eq. (6) we have

$$V^2 = \frac{25{,}000 \times 10 \times d}{5\,000 \times 0\ 384} = 130\,d.$$

Assuming d to be 5 inches, then $V^2 = 650$, and $V = 25\ 5$. Now from Table I. the discharge would be 8.18 × 25.5 = 213 cubic feet, so that this diameter of 5 inches will be quite suitable.

4 *Given an* 8 *inch pipe* 2,000 *feet long, with an initial gauge pressure of* 60 *pounds, and a final pressure of* 55 *pounds, what will be the volume of compressed air discharged, and the volume of free air required?*

Here $F_p = 60 - 55 = 5$ pounds, inserting which in Eq. (6) we have

$$V^2 = \frac{25\,000 \times 5 \times 8}{2{,}000 \times 0.384} = 1{,}302.$$

Whence $V = 36$ feet per second.

By Table I. the volume of discharge will be 36 × 20.944 = 754 cubic feet, and the volume of free air required $\frac{754}{0\ 2}$ = 3,770 cubic feet.

The calculations for the flow of gas in pipes are of the same nature as the above, the formulæ being merely somewhat modified to suit the altered conditions. Thus, in place of Eq. (1) we have

$$D = V \times d^2 \times 19.635 \qquad (8)$$

the discharge being in cubic feet per hour; and in place of Eq. (5)

$$F_p = \frac{V^2 \times l \times s}{c \times d} \qquad (9)$$

Where s = specific gravity of the gas, air being = 1;
l = length in yards;
F_p = friction pressure in inches of water;
c = a constant varying between 2,600 and 4,700 according to different authorities.

Multiple Expansion Diagrams.

BY CHAS. M. JONES.

In a former article a certain alleged design of a triple-expansion engine was mildly criticised, the cards being worked out on the supposition that the cylinders were connected tandem.

Opportunity has since been taken to construct diagrams for the given engine, cross-compounded, and Figs. 2, 3 and 4 are the result. It may be remembered that when the original paper—the subject matter under discussion—was read, certain eminent men "rose in assembly," and stated, unblushingly, that they were in the habit of *guessing* at cylinder proportions for multiple-expansion engines, for the reason that *they knew of no methodical process* of formulating a design.

Lest the younger members of the profession imbibe false notions as to the state of steam engineering practice, by perusal of the above quoted confession, the cards are here given in such detail as seems necessary to thoroughly explain the main features of a rigid method of analysis applicable to engines of any type.

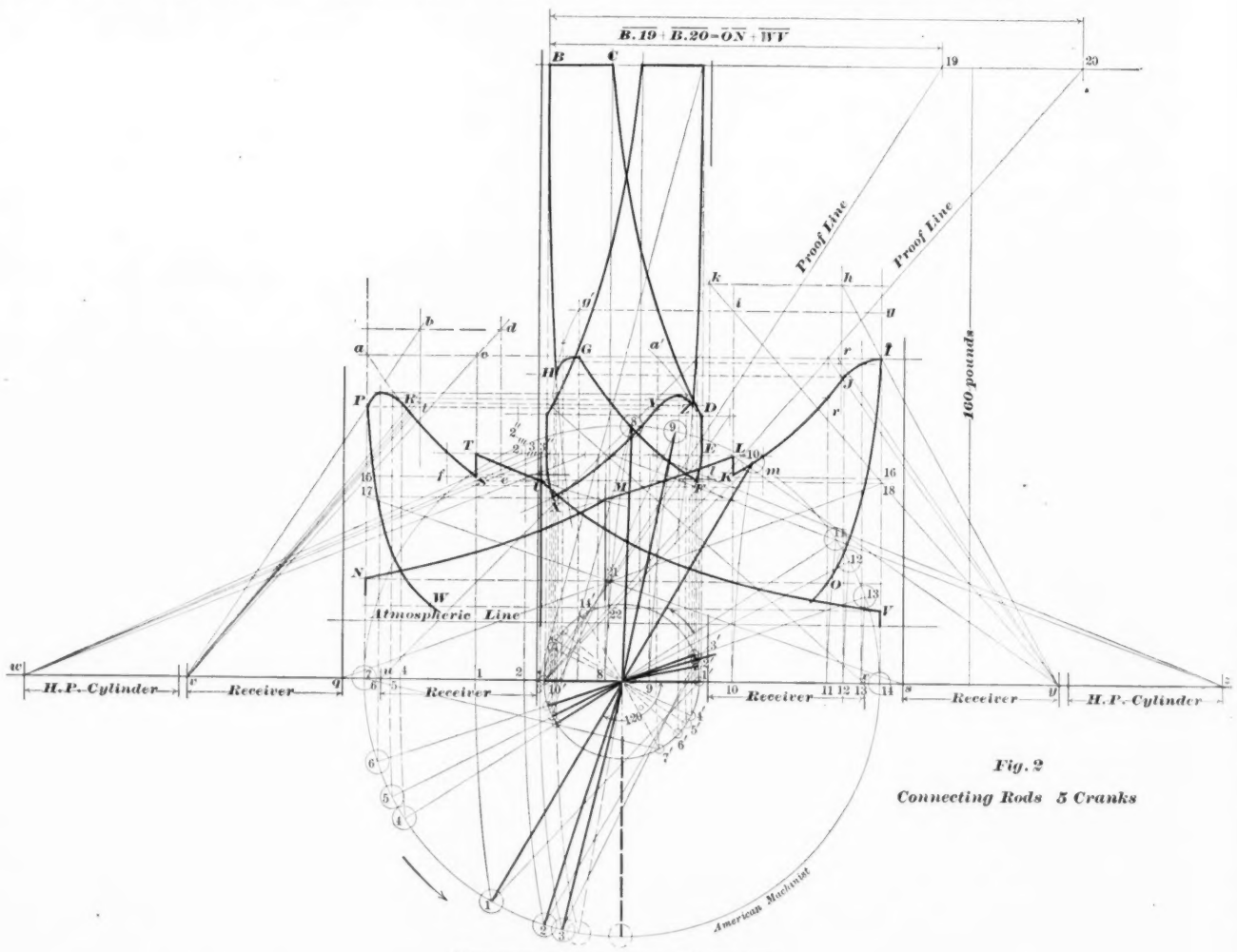


Fig. 2

Connecting Rods 5 Cranks

MULTIPLE EXPANSION DIAGRAMS.

Figs. 2, 3 and 4 are the H. P. and upper portions of I. P. cylinder diagrams of a triple engine, in which the cylinder ratios are 1, 3.3, 13.2 (the L. P. cards are not given, on account of space required), and the H. P. clearance is 5 per cent. of swept space, while the I. P. clearance is 4½ per cent.

NOTE.—The receiver is equal in volume to the H. P. swept space.

Steam at 160 absolute is cut off in H. P. cylinder at 0.4 of stroke.

In Fig. 2 the H. P. crank leads by 120°, and when at release point D, the I. P. piston is at 1.

In these diagrams the crank circles are struck to represent by scale the swept spaces of the respective cylinders. The piston position for any particular crank angle, being found by striking from the crank-pin point an arc, the radius of which is equal to the connecting rod multiple of the actual throw of crank.

Sweeping the arc 1, 1, and erecting a vertical at the latter point on $w\ z$, such vertical is at the I. P. piston position when the H. P. releases at D.

Allowing 10 pounds drop, E is the drop point, and a horizontal, $E\ T$, cuts the I. P.

piston line 1 T c at the proper pressure point 7.

Before H. P. release there was a volume of steam in the receiver and I. P. cylinder equal to v 1, and such steam was necessarily at a less pressure than 1 T, since the H. P. drop would compress v 1 to a less volume by the space required to expand the live steam to the drop point.

From the H. P. origin (the intersection of H. P. clearance and base lines) draw a diagonal through the drop point E. The intersection of such diagonal, with a horizontal from D, gives the additional space into which the live steam must expand to fall to E, and this is the amount of compression to which the steam in receiver and I. P. cylinder will be subjected at H. P. release.

Take $S\,f$ equal to the above compression, and draw the diagonal v T (not shown on diagram). This diagonal will cut the vertical drawn at the distance $S\,f$ (this distance $S\,f$ is laid off from T, since S is not yet determined) at a point f, which is the pressure point at which the steam in receiver and I. P. cylinder must be at the instant before H. P. release, in order that such release shall raise the lower steam to the T point while the live steam drops to E.

Drawing $f\,S$ horizontal, S is located as a card point for the I. P. piston position 1, for the instant before release.

Since the I. P. was open to the receiver while traversing the space 7, 1, S is a point on a "drag line," the origin of which is v, and drawing a diagonal from v through the point of intersection of $S\,f$ horizontal and 7 a vertical, its intersection with a vertical from S gives c as the initial pressure point *due* to the drag line.

A horizontal from c gives a as the actual initial point, and $S\,a$ is thus located.

But by reason of the small H. P. clearance when the I. P. is at 7, the H. P. at 7′ has not yet cushioned, and at the instant before I. P. lead, the H. P. exhaust side of piston is at a pressure due to a certain banking line.

The total volume of steam in both cylinders and receiver *after* H. P. cushion is equal to $v\,1$ + H. P. cushion value, and this is also the equivalent amount throughout the connection. At the pressure height 1 S draw a horizontal across the right-hand H. P. cushion and initial (clearance) lines (the cushion lines being first drawn indefinitely, as shown by their continuations below H and Z), and add the volume thus cut off to that at S, as shown by $S\,e$. Draw a vertical at e, and its intersection with the diagonal $v\,c$ gives d as the pressure point that *would* result if the total volume of steam in I. P. cylinder, receiver, and H. P. clearance was compressed in the receiver and I. P. cylinder *alone*.

But the actual total space between pistons when I. P. is at 7 is equal to v 7 plus the H. P. clearance and exhaust space due to 7′, and setting off this increase from a and drawing a vertical through such last point, a diagonal $v\,b$ (b being at the pressure value d), cuts 7 a at P, and this is, therefore, the initial pressure point of the I. P. cylinder.

At the instant before the I. P. reached 7 the H. P. was banking up in the receiver, and assuming that the curves run smoothly into one another at such points (without drop or rise), P is also the pressure on the banking line of the H. P. when 7′ is reached by the latter piston, and this at once determines Y, and from Y the banking line $Y\,X$ is readily drawn, the receiver point x being the origin.

Starting from P with the initial total volume v 7 plus the distance or space from a to the line $b\,t$, draw $P\,t$ horizontal, and on it, from t, lay off the increase due to I. P. piston motion, less the decrease due to H. P. piston, and through the volume points so found for several crank positions draw diagonals from v. The intersections of such latter lines on the vertical $b\,t$ give the pressure points as shown between P and R, and these pressures being also transferred to the corresponding H. P. piston positions $Y\,Z$ is drawn.

Since the H. P. at cushioning must leave the I. P. on the line a S, $Y\,Z$ must cut the H. P. cushion line at the same pressure at which P R cuts the drag line a S, and if it does not an error has crept in in plotting.

As a check transfer points cut on $a\,R\,S$ by I. P. piston positions near R to the corresponding H. P. piston positions, and through such transferred points draw a curve as shown by the thin line $a'\,Z$. This latter curve will cut the H. P. cushion line at the proper H. P. piston position, at which $P\,R$ should merge into or cross $a\,S$.

Having thus located $T\,S$, $S\,R$ R P and $Z\,Y$ and $Y\,X$ (the *point* X to be found later) start the I. P. piston from 1 at T pressure, and on 7 E add the I. P. space 1, 2, and from the point so found set *back* the corresponding volume rejected by the H. P. piston, and draw diagonals from w through the corrected volume points thus located. These diagonals will intersect the initial line $T\,1$ at the proper pressure points, which latter being transferred to both I. P. and H. P. piston positions, give the lines T U and $E\,F$.

These lines are first drawn indefinitely (as shown light), and $I\,J$, $H\,G$, and $G\,F$ are then found by the same means as was used to locate the corresponding lines $P\,R$, $Y\,Z$ and $Y\,X$.

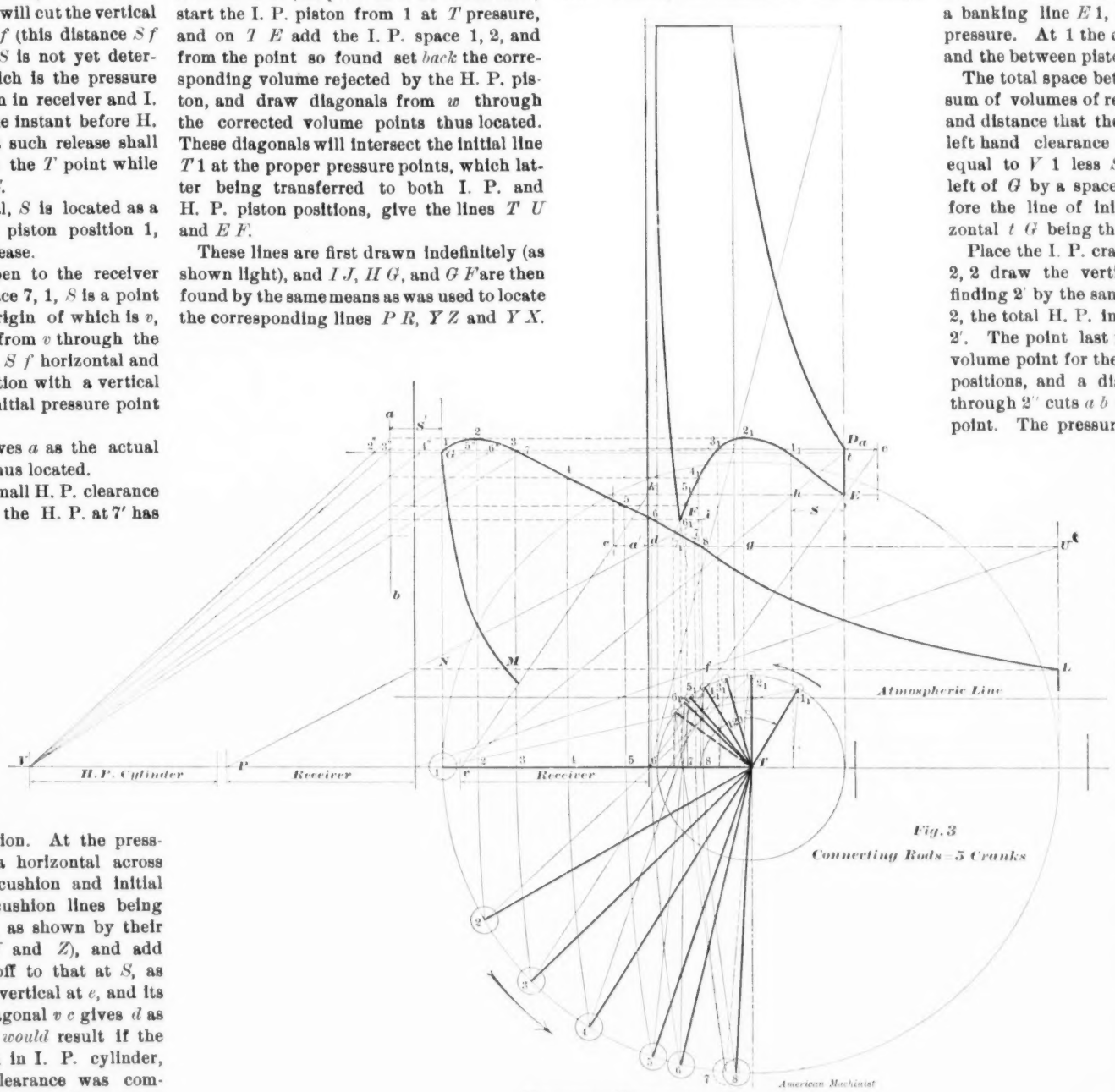


Fig. 3
Connecting Rods=5 Cranks

MULTIPLE EXPANSION DIAGRAMS.

$G\,F$ cuts $E\,F$ at F, which is the H. P. point at which the I. P. left-hand card cuts off, and locating the I. P. position either by a horizontal from F to cut $T\,U$, or by spacing around from the H. P. crank the proper angle, or, better, by both methods, which check, the position 3 is found, giving U as the I. P. cut-off for left hand card.

In the same way, the points X and M are determined for the right-hand cards, and the construction is complete.

If the I. P. cushion is but partial, J and R are in general shifted, since the total equivalent quantity of steam between pistons is varied. The modifications for such cases are readily worked out, and seem to require no detailed explanation.

L and T being here fixed, determine the remainder of the work, and the absurdity of attempting to arbitrarily settle—beforehand—the cut-off, drop and cushion, is readily comprehended.

The right-hand cards are both of greater area than the left-hand set, and to equalize there must be changes made in H. P. cut-offs, drop and I. P. cushion. Either or all of these factors can be made to assist in securing the desired result.

It will be noticed that line $P\,R$ first rises from the lead point, and this is often mistaken in actual engines for want of port opening.

Larger clearance volume in the H. P. cylinders—sufficient to allow the banking lines to strike the cushion *directly*—would better the cards.

It may be well to state right here, that the abnormal craving for close clearance, the outward expression of which in pamphlet form by certain enthusiastic experts gorges the junk shops on both sides of the water, is not altogether based on a thorough appreciation of facts. The drag and banking lines are due to absorption from, and compression in, the receiver, which is then virtually the clearance; and although the steam therein does not fluctuate to the extent of the total cylinder limits of pressure, yet in view of the much greater volume over the waste spaces in cylinder, as well as the—generally—enormously greater metallic surface, if clearance loss was anything alike that popularly assumed, the multiple expansion engine would occupy a select corner of the scrap heap.

In the figure U V and M N are the expansion lines in I. P. cylinder after cut-off; N and V being the I. P. terminal pressures.

Draw N O and V W, and intersect these lines by verticals, the horizontal distances between which are equal to the volume of steam cut-off in H. P. cylinder (both H. P. cut offs being here equal, and cushion full, $B\,C$ is simply projected down to cross both terminal lines). Take any convenient point on line of zero pressure ($w\,z$) and from it draw pairs of diagonals, through the proper intersections of the verticals, with the horizontal terminal lines. As, here, 10′, B, 10′, 19; 10′, B, 10′, 20. The *sum* of the volumes cut off by such *pairs* of diagonals on the line of initial pressure, will be equal to the *sum* of card lengths cut-off by the horizontal terminal lines. If not so equal, some mistake has been made.

The amount of steam in *either* end of lower cylinder at cut-off, is not *necessarily* equal to that in upper cylinder at the closing of the latter's valve, but the *sum* of volumes due to *both* sides of pistons, must be so equal for all cylinders, and this the proof lines will show for proper adjustment. If this point is not attended to, there will be either a permanent change in the cards, or a cyclic fluctuation of pressures.

In Fig. 3 the I. P. crank leads by 120°, which, with the given proportions, produces a much better result than Fig. 2.

When the I. P. piston is at 1, the H. P. has already swept out the space $E\,h$ ($= S$), and 10 pounds drop being here allowed, the H. P. steam after dropping, again rises on a banking line $E\,1$, to almost the release pressure. At 1 the cylinders communicate, and the between pistons line is to be plotted.

The total space between the pistons is the sum of volumes of receiver, I. P. clearance, and distance that the H. P. piston is from left hand clearance line, and this being equal to V 1 less S, $a\,b$ is drawn to the left of G by a space $S' = S$, $a\,b$ is therefore the line of initial volumes, the horizontal $t\,G$ being the initial pressure.

Place the I. P. crank at 2, and sweeping 2, 2 draw the vertical or piston line, and finding 2′ by the same means, set *back* from 2, the total H. P. insweep between E, and 2′. The point last found (2′) will be the volume point for the given crank, or piston, positions, and a diagonal from V passing through 2′ cuts $a\,b$ at the proper pressure point. The pressure point so found being transferred to the I. P. and H. P. piston positions gives a card point for each cylinder.

Plotting the various points, as shown, the H. P. cushion line is finally cut by the back pressure line at P (which corresponds to 6), and here the H. P. must cushion.

But on making $a' = a$, and drawing the diagonal r k, the receiver pressure, into which the live steam must drop, is given by the c point, and as this is less than the H. P. cushion pressure F, the I. P. must "drag," until the receiver is reduced to the given proper value.

The drag line between 6 and 8 has P as origin, and at 8 the proper pressure having been reached, the I. P. cuts off, and the steam expands in I. P. cylinder alone to L. In this figure the receiver pressure fluctuates between wider limits than does the H. P. back pressure. The right hand cards have not been drawn. In actual designing they would be required, as in almost all cases re adjustments, to equalize areas and fluctuations, are necessary.

Fig. 4 is alike Fig. 3 except that there is no drop.

The H. P. line D 1″, 4″, E does not cut the cushion curve at the pressure valve D, and, therefore, a banking line $w\,E$ is necessary; w determines E, r being the origin of the curve, and a vertical through w the line of initial volumes.

E fixes the I. P. cut-off 6, and 6 L is the I. P. expansion line, O being the origin.

This is the best card of the set, the temperature and pressure limits of receiver and connected cylinder surfaces being less than in either of the preceding cases.

In working out multiple cards by this process the only assumption made is that the equation of the steam curve is $p\,v =$

constant. After the cards have been properly adjusted, and the actual receiver and cylinder sizes, and metallic areas in steam contact closely approximated, the refinements called for by thermo-dynamic principles are readily included, and the final corrected sizes and cards trimmed for port resistance, and steam column inertia, condensation, etc., laid down.

It may be objected that the herein explained method requires too much time for regular practice—that, armed with confidence, a sharp pen, and a properly credentialed quack formula, the aspirant for engineering honors and emoluments can lay down the sizes, cushions, cut offs, and all main details in a half-hour's *seance*.

In reply, it should be dispassionately pointed out that in spite of the frantic efforts of our electrical friends to consign the steam engine to oblivion, close competition is rapidly raising the standard of performance, and in a very few years a class of formula flingers that now holds sway in many engineering establishments will find themselves upon the cold and cheerless world unable to obtain a professional engagement.

As the fluctuations of pressure and temperature between cylinders and in receiver are mainly due to the variations of volume between pistons, and as such variations are a direct function of the cylinder ratios, the closer the relation of trailing or lower cylinder volume to the capacity of the leading or upper cylinder, the more uniform in general will be the pressure in the connected spaces, and the greater the economy of the engine as far as such between-cylinder-factors enter the problem. Such being the case, it follows that a *properly designed* quadruple-expansion engine *must* give a very marked economy over a triple, both carrying, say, 160 pounds of steam, and expanding to the same terminal pressure.

The discussion of loss by drop is reserved for another article.

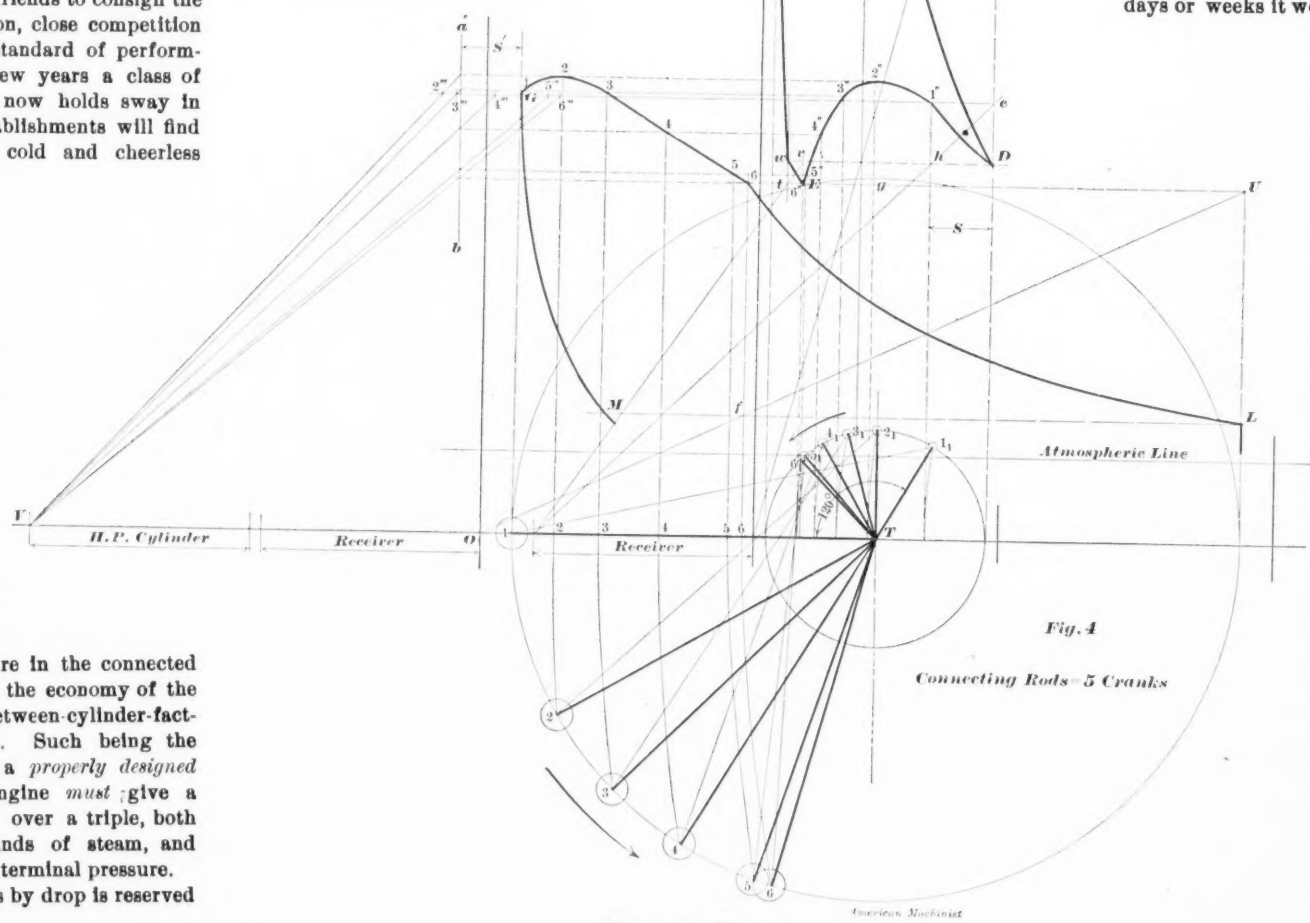


Fig. 4

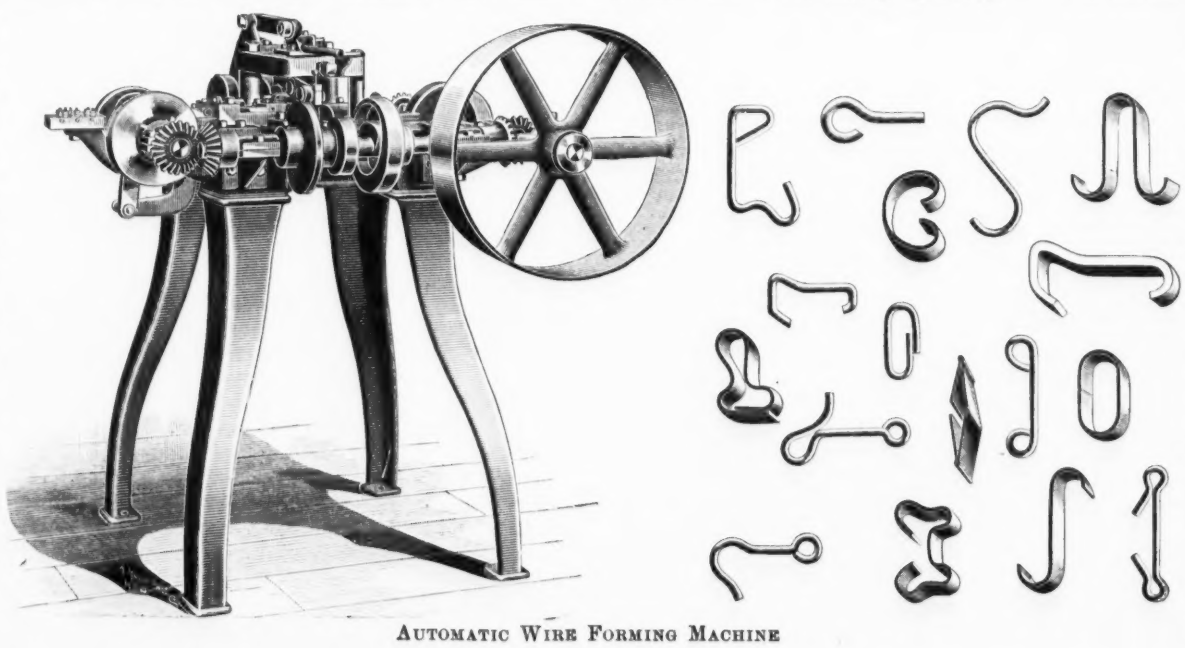
MULTIPLE EXPANSION DIAGRAMS.

Boiling Water in an Open Tube Without Fire.

At a meeting of the British Association, Section A, Mathematical and Physical Science, as reported by *Engineering*, Professor Osborne Reynolds, F. R. S., showed an old experiment of his never before published. The state in which a jet of water will issue from a tube which is contracted in one part, depends upon the velocity and the pressure. He simply held a glass tube, drawn out in its middle part, under the tap. At first the water issues in a smooth steady jet. Then eddies form below the contraction, but the jet is still smooth. In the third stage, turning the tap on more fully, the motion becomes turbulent. Finally, air bubbles form below the contraction, the column is broken, and hammering and hissing is heard. The pressure below the contraction has fallen below the atmospheric pressure, and the water is actually boiling there. When the tube is dipped into a beaker filled with water, a condensation cloud may be seen within it. The phenomena have their parallel in the hissing of a kettle just before boiling, and in the noise made by the water rushing out of a bath, which never seems to have been thought worth inquiring into. The third and fourth stages, Professor Reynolds said, are not quite clear mathematically.

Automatic Wire Forming Machine.

We present below engravings showing a small wire forming machine, and a few representative pieces of its work. It will feed any length up to 1½ inches of wire at a stroke, and forms it by means of plungers, which are moved by cams placed upon the system of shafts, which extend round all four sides of the table, and are connected by bevel gears, as shown. The former at the center, about which the piece is formed, is moved vertically at the proper times to produce the desired result, this former being made under the patents of Mr. F. B. Manville, superintendent of the shop in which the machine is built. The machine will make from 80 to 120 pieces per minute, and is built by Blake & Johnson, Waterbury, Conn.



AUTOMATIC WIRE FORMING MACHINE

At this writing, the efforts of the contractors to get a trial run out of the new torpedo boat, the "Ericsson," have been a series of misfortunes. After repeated breakages of an eccentric strap, an air pump broke down just as the vessel was about to pass over the line at the beginning of the course, and when it is said that she was running about one knot less than her contract speed—24 knots.

Naval engineers claim that the vessel can be made run at her contract speed without breaking down, and that it is the fault of the men in charge of her that she has repeatedly failed. They assert that a regular naval crew should be substituted for the "Mississippi River men" who have been in charge of the vessel.

Since the above was written the "Ericsson" in still another preliminary run broke a low-pressure piston rod, wrecking the cylinder and necessitating probably a delay of many days before she can be again tried. Whether or not the claims of the naval engineers mentioned above are correct, it is very evident that something is wrong, and that either the engines are not well handled or are being driven beyond their capacity to hold together.

LETTERS FROM PRACTICAL MEN.

The Disappearance of the Mysterious Disappearance of Compressed Air.

Editor American Machinist:

I wish to thank Mr. Olin Scott for his contribution November 8th to my stock of knowledge upon the subject of compressed air, and for the instance which he cites from his own practice of at least one place where under trying conditions compressed air may be and is held securely, and does not mysteriously disappear. It appears that in the case that Mr Scott cites, about 11 cubic feet of free air contained in a 12 inch pipe and compressed to, say, 1½ cubic feet, would in his earlier practice mysteriously disappear. The rate of disappearance is not clearly indicated. It appears only that "after several days or weeks it would *begin* to leak away. Say that it all leaked away—an operation that never to my knowledge was called a "mysterious disappearance" until compressed air got at it—say that it all leaked away, the whole 1½ cubic feet, in a month. A 12 inch pipe is capable of easily transmitting, at, say, 90 pounds pressure, 10,000 cubic feet of free air per minute, which is 432,000,000 cubic feet per month. Say that a mile of 12 inch pipe has 500 joints, and that each of the joints leaked as above. Then in a month of constant flow as much air would be lost by leakage as would flow through the pipe in half a minute. This would be enough to run all the rat traps in the country.

But the valuable point of Mr. Scott's letter is in the proof that he gives us that even this rate of leakage or of mysterious disappearance may be cured. We learn that while air will in time percolate through uncooked red lead, and I didn't know it, it will not go through the red lead if it has been subjected to a moderate heat for a time, and we learn also that the air will not sneak through a thin film of pitch, which I for one am very glad to know.

Under the conditions mentioned by Mr. Scott, it is by no means clear that steam would not leak where it was clearly proved that air did leak. Mr. Scott says that after finding out that the air actually leaked away he "*knew* that the same means of fitting the pipe to hold a like steam pressure would not hold the air." This is a thing that cannot be proved, although it apparently may be "known." A cubic foot, or a foot and a half of steam at 90 pounds pressure, cannot be retained in any receptacle for a month, as the air was, with any possibility of detecting whether or not any of it escaped. What Mr. Scott's experience actually seems to prove is that, as between steam and air, the means of fitting that seems to hold steam under certain conditions, will not hold air under other and widely different conditions. The ablest investigators of the "duty" of steam boilers and engines are never able to account for all the water that disappears between the boiler feed and the engine load. We

are apt to say that steam leaks are always discoverable either by the noise or by the water produced. Minute steam leaks amounting to much in the aggregate may exist without either of these indications. Keep a boiler fired up and under pressure for a month without any apparent outlet of steam and will not some of the water disappear? Are there not disappearances of steam, or of water in connection with steam, more mysterious than any that are to be found with air? FRANK RICHARDS.

That Wonderful Cupola.

Editor American Machinist:

I did not intend to write upon this subject again, but the assertions of Mr. Durfee and others led me to inquire into the subject farther, to ascertain if there was any mysterious chemical benefit to be derived from the system of tuyeres used in the Greiner cupola, or if their success was not due to management alone.

The following has been the result of my investigations: In the first place, the tuyeres above the melting point are not necessary to produce perfect combustion, or to convert carbon dioxide or carbon monoxide into carbonic acid. If a sufficient volume of air, properly distributed, be admitted below the melting point, and the iron and fuel charged as they should be, carbon dioxide or monoxide will not be formed, and when they are it is due to mismanagement.

I am at present running a cupola 40 inches in diameter, as shown in AMERICAN MACHINIST, September 20th, and my ratio of fuel runs as follows: When the scrap is heavy, 1 to 22.7; when scrap is medium, 1 to 25; and when very light 1 to 2.75. We make good hot iron, suitable for any general work.

This must be understood to mean the ratio of iron to fuel in each individual charge, but when the bed is added it will make a varied record of from 1 to 10 up to 1 to 15, according to length of heats. You will also see it means melting a ton of iron with the following amounts of fuel depending upon the proportion of scrap:

30 per cent. pig, 70 per cent. heavy scrap, 88 pounds per ton.

30 per cent. pig, 70 per cent. medium scrap, 80 pounds per ton.

30 per cent. pig, 70 per cent. light scrap, 72.72 pounds per ton.

This is done every day with a cupola that makes no pretensions to chemical advantages, and is based on common-sense practice, and a knowledge of the principles of melting.

No flame appears at the charging door while the cupola is full, and a remarkably small amount of heat. This is the reason I do not believe the Greiner apparatus is the cause of the records they show.

Chemistry does not appear to reach the difference in weight of scrap iron to be melted; very heavy scrap requires from 40 to 50 per cent. more fuel than stove plate, and yet when an equation is written it takes none of these things into consideration.

Chemistry is undoubtedly one of the greatest helps a foundryman ever will have to help him solve many of the knotty problems that so often have confronted him in the past and will in the future, but it must be applied practically, and by men who understand the common conditions and circumstances they have to deal with, not in the laboratory by the student who knows naught but his equations.

To satisfy myself fully upon the subject, and prove what I had acquired by a close study of the matter, I instituted some inquiries among those using the Greiner cupola.

A report comes from Geo. Q. Thornton, President of Carondelet Iron Works, St. Louis, Mo., from which I take the following facts: In the summer of 1892 they received a letter from the Greiner Economical Cupola Co., inclosing several copies of letters of recommendation, offering to apply their system of tuyeres to their cupola, and guaranteeing a saving in fuel of 15 per cent. After instituting inquiries, to which they received favorable replies, they closed a contract to equip their cupola with the apparatus. The device was put into operation in November, 1892, being finally tested and adjusted by the Greiner agent.

During the first month of its use, the ratio of fuel was 1 to 8.08 down to 1 to 8 65. As the previous record had been about 1 to 7, Mr. Thornton, who had given little attention to the matter, considered that the guarantee had been filled, and so advised the superintendent, Mr. Crawford. The latter, however, stated that in his opinion the device in question had very little to do with the saving made in fuel, and wanted more time for experiment. The final test was as follows: For six days, ending January 14, 1893, Greiner apparatus carefully disconnected: Iron melted, 234,480 pounds; coke, 23,690 pounds; ratio, 1 to 9 90. For six days, ending January 21, 1893, Greiner apparatus attached: Iron melted, 238,270 pounds; coke, 24,430 pounds; ratio, 1 to 9.75.

This satisfied them that the improvement was not due to the Greiner apparatus, and they accordingly abandoned it. The cupola measures 48 inches inside the brick, and the heats averaged 20 tons daily. Their present practice, partly the result of the instructions of the Greiner Company, and partly due to experiments of Mr. Crawford, gives a ratio of about 1 to 9, and a little better, and gives hot iron for the lightest castings, enabling them to melt fully ten tons per hour. The only reason they can give for their previous poor performance, is that they had left the matter of charging entirely to their foundry foreman, and had not taken pains to find out what was the best result they could get.

This is the experience of two of our representative foundrymen, Mr. Thornton and Mr. Crawford, who, when their attention was directed to the matter, thought for themselves, and solved the problem many pay a good price for. Unquestionably, the Greiner Cupola Co. understand their business, and how to run and manipulate a cupola, but the claims made for the upper tuyeres and their action and benefit, is a fallacy anyone can prove by close attention and application.

As a result of study and careful investigation the mystery of remarkable and phenomenal performances resolves itself into practical, everyday occurrences.

HERBERT M. RAMP.

Springfield, Mo.

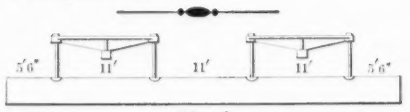


Fig. 2

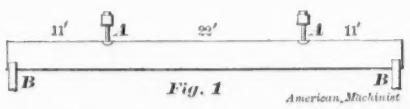


Fig. 1

The Henry Clay Colliery Explosion.

Editor American Machinist:

I had expected before this to have seen much more in the way of information, speculation or remark about the wholesale boiler explosion at the Henry Clay colliery. It should have attracted the attention of every one interested in the use of steam, and it should have incited many to say something about it, for it would seem that there are many things that should be said. It is not often that we have things done so thoroughly as in this explosion, and the question must have arisen in some minds as to why the remaining nine boilers out of the thirty-six did not explode at the time, and make the job complete and unique. Mr. Le Van apparently had no difficulty in finding sufficient and satisfactory evidence of the cause of the explosion in the material of which the boilers were made, and this might be accepted if Mr. Le Van had not in his account of things furnished us with evidence of other conditions contributing to the catastrophe. That none of the longitudinal seams of the boilers gave out is a remarkable circumstance, and in itself is a sufficient proof that the steam pressure and the defective iron were not alone the cause of the explosions. The giving out of the transverse joints in connection with the sketch of the mode of suspension shows that the boilers were subjected to considerably more strain than that of the internal pressure.

I do not pose as a steam boiler expert, but I long ago learned to have considerable respect for the weight of a boiler itself, and of the water contained in it. I remember how, a great many years ago, a couple of boilers of the same style and of about the same dimensions as those of the Henry Clay colliery, were placed upon two horizontal timbers, the timbers being, say, six feet from the ends of the boilers, and the boilers were then filled with water preparatory to putting on the hydrostatic pressure for testing. The weight of the boiler, and of the water contained in it, actually crushed in the shell of each boiler, so that where it rested upon the timbers it was flattened in to a depth of about three inches, or the length of the flat or chord resting upon the timber was, I should say, about 20 inches.

Now, not to go into the mathematics of the thing, when we think of those exploded boilers, suspended as they were by bolts attached to saddles placed 11 feet from each end, the overhanging end weighing with the water in it about 2½ tons, the mode of attaching the saddles also probably weakening the shell at the spot where the greatest tensile strain was to be encountered, and, as I learn from another source, the boilers badly corroded by the action of the mine water with which they were fed, we have decidedly more than defective iron as contributing causes of the explosions. It is rather singular that Mr. John H. Cooper, in the AMERICAN MACHINIST, November 15th, while calling attention to this vicious mode of suspension, should have suggested another way of supporting them that is rather worse. He tells of taking out some suspended boilers that were showing cracks at the points of suspension and putting in other boilers, and "they were permitted to rest on their ends, as all such structures should do." Instead of the suspending bolts or rods *A*, Fig. 1, Mr. Cooper employed the supports *B*. He does not say that the boilers of his experience were of the same length and diameter as the Henry Clay boilers, but if they were his mode of supporting them cannot be successfully defended. If the boilers were suspended from four points equitably distributed along their length, and with equalizing beams to adjust the load, Fig. 2, they would be practically relieved from the strains due to their weight, and they would be able to give their undivided attention to resisting the steam pressure.

There are many other interesting points connected with the Henry Clay colliery explosion that I hope to see presented.

FRANK RICHARDS.

Captains Must Command Naval Vessels.

Editor American Machinist:

I notice in this week's [November 15th] issue of the AMERICAN MACHINIST another grind at the line officers in the navy.

I have carefully read the different ones as they have from time to time appeared, and I must confess that they have made me very weary, and from the fact that there are no replies from the line officers, I judge that they do not consider them worth replying to.

I served in the old navy three years, and as I did not rank anything but an ordinary seaman, can hardly be accused of having prejudices on either side; but the absurdity of making the commander of a ship responsible for all that occurs, and then (as those parties who are arguing in favor of the engineers advocate) taking away from him the power to compel obedience to his orders, is so apparent to even a casual observer as to appear ridiculous.

As I understand the present regulations in the navy, an engineer—if he doubts the wisdom of an order—has the right to demand that it be given to him in writing before he can be obliged to obey it, so should things go wrong he can show that he obeyed orders, thus placing the blame where it belongs.

In the winter of 1862-3, I was serving aboard the gunboat "Sonoma," in the West Indies, Commander Thomas T. Stevens. Through continued service her boilers were in such condition that the chief engineer advised the commander that he did not consider it safe to carry over 45 pounds of steam. She had low-pressure boilers, gauged to 60 pounds. Shortly afterwards, in crossing the Bahamas, we sighted the Confederate steamer "Florida," and soon were booming along after her under 55 pounds of steam. But on a young engineer taking charge in the engine-room, the steam was allowed to run down, simply because he was afraid of his own precious carcass. After a couple of messages, ordering him to keep the steam up, which were not obeyed, Commander Stevens sent him word to "open her wide open and keep her wide open, or he would put a marine over him with a loaded musket, and orders to shoot." I can vouch for the message, as I was messenger boy, and carried it myself.

Now, suppose the engineer had the authority to reply that he was carrying all the steam it was safe to carry, and he wasn't going to carry any more. What would the Navy Department and the country have said, when *all* was not done that might have been done to capture the "Florida"? Would the commander have been allowed to escape criticism by simply saying that the engineer didn't think it safe to carry any more steam? I rather think the country would have demanded at once that one man, and one only, be given chief authority, and that he be held (as at present) strictly responsible for all that occurred aboard his ship.

After three years experience with them, I have no hesitation in saying that the regular line officers of the U. S. Navy are gentlemen, and that no officer or man that is disposed to do his duty need have any trouble with them. They are at all times disposed to be as lenient as possible, but there are times, like the case cited above, when the commander of a ship *must be* in command.

FORECASTLE.

The Factor of Safety in Machine Design—Spacing Holes.

Editor American Machinist:

I notice that Mr. Binsse, in your issue of November 15th, page 7, decries the use of safety factors, and advocates parallel rather than tapering beams, and wants to make them with their tensile and compressive members of like section, in such materials as cast iron. It is undoubtedly true that too much dependence is sometimes placed on the so-called safety factor of a structure, but this is probably rather the fault of the factor itself than of the fellow who uses it. All this only goes to show the need of more careful study and more frequent discussion as constituent elements in arriving at the best practice.

I cannot agree with Mr. Binsse in the other points mentioned, although it is well, of course, in each individual case to consider carefully whether we really want uniform strength or uniform deflection, or, as is perhaps most frequently the case, a modicum of both. As a matter of fact, it would be very dangerous practice to greatly lessen the section of the tensile member in frames of presses and other cast-iron constructions subjected to heavy and intermittent stresses. If, on the other hand, the compressive member was made equally large and parallel therewith, such practice would, at the very least, be rather expensive, to say nothing of its uniqueness.

If this is not too personal, it may be of interest to relate that a most excellent boring machine which I am now using, and one which is always selected for taking the heaviest cuts in the shop, for the reason that it embodies a great deal of the "anvil" doctrine, being unusually massive, was designed and built by Mr. Binsse. Moreover, one of the most graceful castings on this machine is a projecting beam supporting the spindle slide, which has a very heavy tensile member, and which is of a genuine parabolic (and conventional) form.

By all this I judge that the maker of this machine also has "a horror of bending action," in common with the gentleman to whom he refers in his seventh paragraph, and with whom, by the way, I should doubtless enjoy an acquaintance, should an opportunity ever occur—he seemingly holding certain doctrines of a similar nature to my own. If, however, he would make only three times the cross section in the tensile member of a press frame, as compared with the compressive, as Mr. Binsse states, I should amend the ratio to 4 or 5. I have noticed that when such a frame is overstrained it always cracks on the *tensile side!*

Criticising further your recent correspondents, I find that Mr. "Easy Way," on page 10 of your November 15th issue, has made my name and my recent article upon "Spacing Holes" a text for an interesting sermon upon die making, etc. Much of what he says is true, and his suggestion for grouping a number of cylindrical dies clamped together in a frame, as shown in Fig. 17, is to me new and seemingly valuable.

The writer in question, however, has evidently entirely misunderstood my article, as I did not attempt to write especially upon die making, but only referred incidentally to the block of steel in which three holes were accurately bored, not laying any stress upon the fact that it was for a female gang die. Your correspondent mistakenly speaks of this being a method to replace an obsolete die, which would fit a group of punches already in existence. This was not the case, as the whole construction was entirely new. It was, however, a proper and correct way of making the die, because it was not intended to be hardened, and therefore was not in danger of warping out of true. The method for boring the block to hold the punches through this die was correct, because said block was also not to be hardened—the only hard pieces being the cylindrical punches which were ground true after hardening, and driven into it. The criticism therefore, in the light of these cold steel facts, loses all its force.

I am well aware that where a die of this kind is to be hardened, and where moreover the holes must be as accurately spaced, as was necessary in this case, the warping in hardening would probably require an internal re-grinding afterwards, which, of course, would be perfectly feasible in a grinding lathe, by the method recounted by me for internal turning.

Usually, however, gang dies do not require such great accuracy, and the general practice in the shops with which I am connected, in common with most other people's, has been to drill the lower die with reasonable accuracy, by ordinary methods, and, after hardening, use it as a jig for locating the punches in the punch-holder block above, and also in the stripper. It is, of course, a well known fact that with dies of this kind the stripper sometimes acts as a slide bearing for the punches, and must be made equally accurate with the other members of the composite device consisting of the dies and their appurtenances.

The trouble about "adding up" a number of blocks to get measurements, which your correspondent speaks of, is, of course, present when any one is working in millionths of inches, etc., but for the practical jobs of work in question there is no difficulty in so calipering rectangular blocks with an ordinary micrometer as to obtain abundantly satisfactory results, especially where only one or two blocks are concerned.

OBERLIN SMITH.

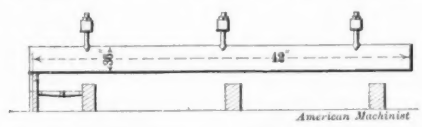
The Shamokin Boiler Explosion.

Editor American Machinist:

I have no desire to apologize for the use of poor material in the construction of steam boilers, but I must say that I doubt whether the immediate cause of the explosion at the Henry Clay colliery was due to the poor and defective material, as described by Mr. Barnet Le Van, in the AMERICAN MACHINIST of October 25th. The number of boilers (27) involved in this accident, and the peculiar manner in which they gave way, renders, I think, a correct knowledge of their condition at the time, a very important matter.

Those not familiar with the particulars of this catastrophe will do well to note Mr. Le Van's account of it, and, coming as it does from one who has made steam appliances a specialty, a value attaches to what is said, that is not found in the ordinary newspaper reports.

I know nothing of this occurrence, except what I get from the above report, and with all deference to the writer, venture to suggest a few thoughts for consideration.



There are, doubtless, a good many boilers in use that approximate the proportions of those used by the Henry Clay mine, namely 36"x42 feet, plain cylindrical boilers, without flues.

I notice that the drawing made by Mr. Le Van (a side elevation) is not made to scale, and therefore does not show the boiler in its true proportions. As shown, two suspension bolts seem to be sufficient, but in my sketch it is apparent that three or four such bolts should have been used. Perhaps for the purposes Mr. Le Van had in view it was not considered necessary to show these bolts as they actually existed.

My object in furnishing the sketch is to demonstrate a weakness in these boilers to resist external strains in a lateral direction.

As more or less of the mysterious element surrounds all boiler explosions, so in this we find things that are inexplicable. One of these is seen in the fact that while 1,134 feet of boiler shell was rent asunder, not one of the horizontal seams, though single-riveted, gave way, and yet these were subjected to nearly double the strain from steam pressure that the transverse seams yielded to. It hardly seems possible, to my mind, that the unequal expansion between the top and bottom of these boilers could thus weaken the transverse seams. Of course, good or bad material would cut no figure in the relative strength of these joints.

When we come to consider the effect of lateral strain, whether that be caused by the upward force of the coal gas, that is said to have exploded under the three boilers first to give way, or by the fall of one end of these boilers, it is obvious that these strains would be thrown almost entirely on the transverse seams, and, of course, their ability to resist them would depend largely on the quality of the material of which the plates were composed.

Assuming that the first boilers to give way, separated near the middle, the full force of this explosion would take effect near the center of the next set, breaking them in two, and so on, in quick succession, until nine batteries of three in each, or 27 boilers in all, yielded to the combined external and internal pressure brought to bear on them.

According to this theory, the only thing that prevented the remaining nine from meeting the same fate, was that while the destruction of the others was in progress, the steam pressure was being reduced by the broken steam pipe, which connected all the boilers together, and when the twenty-eighth boiler was reached there was not sufficient force left to destroy the balance.

If the coal gas theory is correct, then it becomes a matter of great importance in the installation of such a system of boilers, to see that the supports under the beams are made secure, and that cross walls, or, better still, a hearth be provided on which the boilers might fall without injury. In the use of a hearth, arranged, say, 10 or 12 inches from the boilers, it would seem impossible for enough coal gas to accumulate to do any damage, while in large combustion chambers such a thing is possible. I am aware that discussions like this are often desultory, but, as was said in the outset, the unusual nature of this disaster, and the great destruction of life and property attending it, must necessarily attract a good deal of attention.

"QUIRK."

The Shamokin Boiler Explosion.

Editor American Machinist:

Referring to the account of the boiler explosion at the Henry Clay colliery, in your issue of October 25th, and noting Mr. Le Van's statement, "The single riveted horizontal seams, the weakest part of the boilers, did not give way, but the transverse joints in every case did, although considered the strongest of the two," leads to further consideration.

We are too apt to consider strains in such cases as resulting from internal steam pressure alone. They may be complicated by strains produced by unequal temperature, as suggested by Mr. Le Van, and certainly are by strains due to the weight of boiler and contents, and usually to some indefinite extent, also, by imperfect distribution of the weight at the points of attachment of the hangers to the plates.

These strains would all act with greatest intensity on the vertical seams. In the absence of exact information as to weight of covering, etc., it is impossible to state definitely what the stress due to weight would amount to, but making assumptions which are probably near correct, we find strains of 1,000 pounds per square inch of net section at top and bottom of shell due to weight alone.

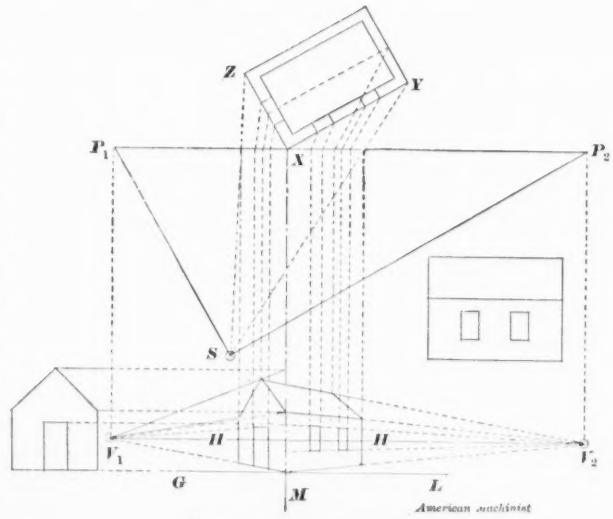
When this is supplemented by probable local or secondary strains due to improper distribution of the weight through the hangers, it is easy to see that there may have been points where the vertical seam had to endure more than the longitudinal seam, which would account for their failure in this case, without assuming that the material was especially bad at the points where rupture began. In other words, these boilers probably broke transversely, due to improper material, and to improper method of suspension. There is abundant precedent for this statement. Some years ago having occasion to examine a case where a long boiler, with a long space between supports, showed decided symptoms of weakness at the bottom of a girth seam, I found that the strains induced by weight alone were much greater than the case under consideration. Inserting a third support over the middle of the length corrected the trouble. The overhang at each end of the Henry Clay boilers was excessive; it should not have exceeded 9¾ feet for boilers of their length, in order to reduce the weight effect to a minimum.

A better plan still, when such long boilers must be used, is to suspend them at several points on equalizing beams to insure a uniform distribution through the hangers. In your issue of November 15th my good friend Cooper, discussing the question, says "it was not known then as fully as now, that strains often repeated and reversed will make the best iron granular," etc.

Perhaps J. H. C has not noticed the awful example of the writer of a recent paper on the failure of stamp rods, and how severely the doctors have sat down on him for resuscitating the crystallization theory. But, perhaps, we had better not burden your columns with a revival of this phase of the question.

JAS. CHRISTIE.

Pencoyd, Pa.



PERSPECTIVE DRAWING.

Perspective Drawing.

Editor American Machinist:

I inclose you a very simple method of drawing perspective. If I had found this 15 years ago I should have lived a happier life at times. Perhaps it will be of interest to the readers of your valuable journal.

In the accompanying drawing the letters denote: S_1 the point of sight; P_1 P_2 plane of the picture. Draw S P_1 and S P_2 respectively parallel to X Z and X Y, which are the sides of the object to be shown in perspective. V_1 is the vanishing point for all horizontal lines in the plane X Z; V_2 is the vanishing point for all horizontal lines in the plane X Y. G L is the ground line. Line of sight is 6 feet above the ground line. Point X where the object touches the picture plane becomes M X, the measuring line on which all heights are measured, and to vanishing point.

OLIVER CROSBY.

[Our correspondent gives the principles of perspective in a nutshell, but, simple as they are, the novice may have some difficulty in understanding and applying them in making perspective drawings of other objects. Those who wish to take up this study and become thoroughly familiar with it should procure a copy of "Davies' Shades and Shadows and Perspective," in which all the above principles are thoroughly explained, and their application shown.—ED.]

Why Does a Bicycle Stand Upright?

Editor American Machinist:

I have been very much interested in Mr. Oberlin Smith's article in answer to the above question. While the article undoubtedly answers the question, it seems to me that there is a much neater way of looking at it.

I have always considered the action of a bicycle as analogous to a child's hoop, with this difference, however, that while with the hoop the action is automatic, with the bicycle it is brought about by the volition of the rider.

Imagine a hoop rolling upon a level surface, and suppose it to lean sideways, as it inevitably must. The very action of leaning diverts the path of the hoop from a straight line to a circle, and the motion of the hoop in a circle at once develops a centrifugal force perpendicular to the radius of the path—that is, parallel to the ground—which force tends to right the hoop. A moment's consideration will show that these two forces—that is, gravity tending to overturn, and centrifugal force tending to right the hoop—must balance. If the tendency to overturn be supposed the greater the inclination of the hoop will increase, which action will diminish the radius of the hoop's path and thereby increase the centrifugal force, which action will continue until the centrifugal force prevents further overturning; in other words, until the two forces balance. On the other hand, if the centrifugal force be supposed the greater it will right the hoop, thereby enlarging the radius of the hoop's path and reducing the centrifugal force. As the motion of the hoop is reduced by the resistance of the ground its inclination increases, and the radius of its path decreases. The effect of this diminished radius is to offset the effect of the reduced speed in maintaining the centrifugal force at a point where it sustains the hoop. It would not in fact be difficult to formulate an equation in which, given the speed of the hoop, its inclination and the radius of the path should be determined.

Now, the action of a bicycle is analogous to the hoop. The rider feels himself falling in one direction, and instinctively guides his machine in that direction, thereby developing a centrifugal force in himself and his machine which tends to right both. As, however, he usually wishes to go in a straight and not a curved path, he in fact overdoes the righting, throwing himself in the opposite direction only to throw his handle bar in the same direction, and so on indefinitely—the difference between a novice and an expert lying in the degree to which the righting is overdone. This action of the machine is, perhaps, clearer on a curved path as in "going about." In this case the inclination of the machine and rider and the action in similarity with the child's hoop are perfectly plain. A straight course is, in fact, a series of reversed curves, the action on each curve being as described. With the old high wheel with its small tires this series of reversed curves was perfectly plain in the path made by the two wheels. With the modern safety with the broad track, due to the pneumatic tire, the track of the two wheels when ridden by a good rider largely obliterate one another. Any rider, however, who has tried to follow a straight line (as, for instance, the slot in the track of a cable road) is well aware of the sinuous nature of his path.

F. A. HALSEY.

Purifying Oil.

Editor American Machinist:

In your issue of November 15th an inquiry is made for an oil filter.

I understand that the oil used in the screw machines becomes foul and viscid. All that is required is that the oil be cleansed and the heavier particles removed. I think this can be done by churning the oil with *clean warm* water, letting it stand long enough for the heavy particles to precipitate in the water.

The machine may be made by turning an oil barrel into an old-fashioned churn with a steam coil, at the bottom, added.

Dayton, Ohio. F. B. HOWELL.

Editor American Machinist:

In reply to your correspondent, "J. L.," who asks for a good method for filtering cutting oil which has become discolored by use, I would suggest that he construct a cheap filter by taking any suitable vessel having a perforated bottom, packing thereon about two inches of cleaned animal charcoal, and on top of which place a layer of clean sand from one to two inches deep. This filter should be kept in a warm place. If the oil is very foul, the sand will require changing at intervals, and when the oil ceases to percolate clear the charcoal must be renewed, or it may be cleaned and used again. This is the simplest and cheapest, and will doubtless answer the purpose. Of course, the size of the filter will depend upon the quantity of oil which it is desired to purify. Many methods have been proposed for the clarification of oils. Amongst the clarifying substances recommended, in addition to animal black, are charcoal, kaolin, plaster of paris, clay and alumina. If clay or a similar substance is used, it should be mixed with the oil, thoroughly agitated and filtered through a woolen bag. A second filtering in this manner may be required to produce the desired result. About five per cent. of clay, magnesite or plaster of paris should be mixed with the oil. A preliminary to any process should be settling of the oil to allow the heavier and coarser impurities to precipitate, from which the oil is then separated by decantation.

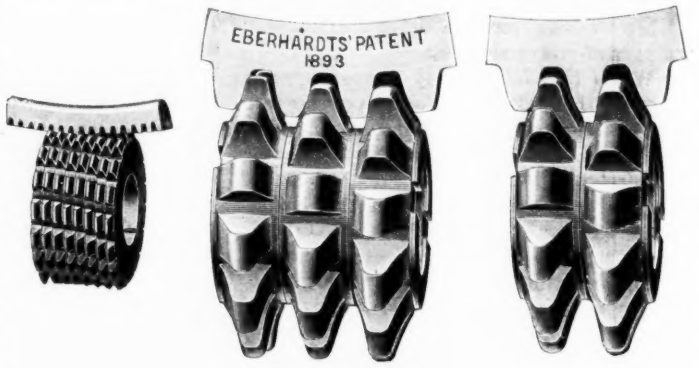
O. VON T.

Driving Ropes.

Editor American Machinist:

With regard to the suitability of rope gearing for low speeds, it may be said that although a fairly high velocity gives the best results generally, speeds of 2,000 feet per minute are not infrequently used with satisfaction, and there appears no good reason why lower rates than this should not be adopted if circumstances necessitate their use. I notice that rope makers do not care to entertain rope gear proposals for speeds of less than 1,000 feet per minute, but this probably arises more from their familiarity with high speeds than from inability to adjust such gearing to special requirements in particular cases. Personally, I know of drives in which the speed is as low as 700 feet per minute, and with which good results are being obtained. The power transmitted is, however, only of comparatively small amount, and the ropes provided are ample for the work.

Of course, as Mr. Booth points out, low speeds give a greater efficiency of transmission than high speeds, since there is less loss due to centrifugal tension. Thus, if we allow a $1\frac{3}{4}$ inch cotton rope at 2,000 feet per minute to be capable of transmitting 30 horse-power, and the same rope at 5,000 feet per minute 50 horse-power, it is clear that the horse power per foot per minute in the first case is 0.015, and in the other case 0.010. But this is a consideration which will not reconcile any man to the necessity for using three ropes at a low speed when two would suffice at a high. Unquestionably, it is desirable to diminish the size of rope driving fly wheels, which, as at present used, are often large and heavy encumbrances. In textile mills, low rope speeds would not be entertained, because fairly high-speed shafting is required throughout. Something might be done in the direction of higher piston speeds, but not very much. If smaller driven pulleys are used, we lose by increasing the power taken to bend the ropes around the smaller radius, and if smaller ropes are adopted wider pulleys become necessary, so that there is a good deal of the "robbing of Peter to pay Paul" about this suggestion.

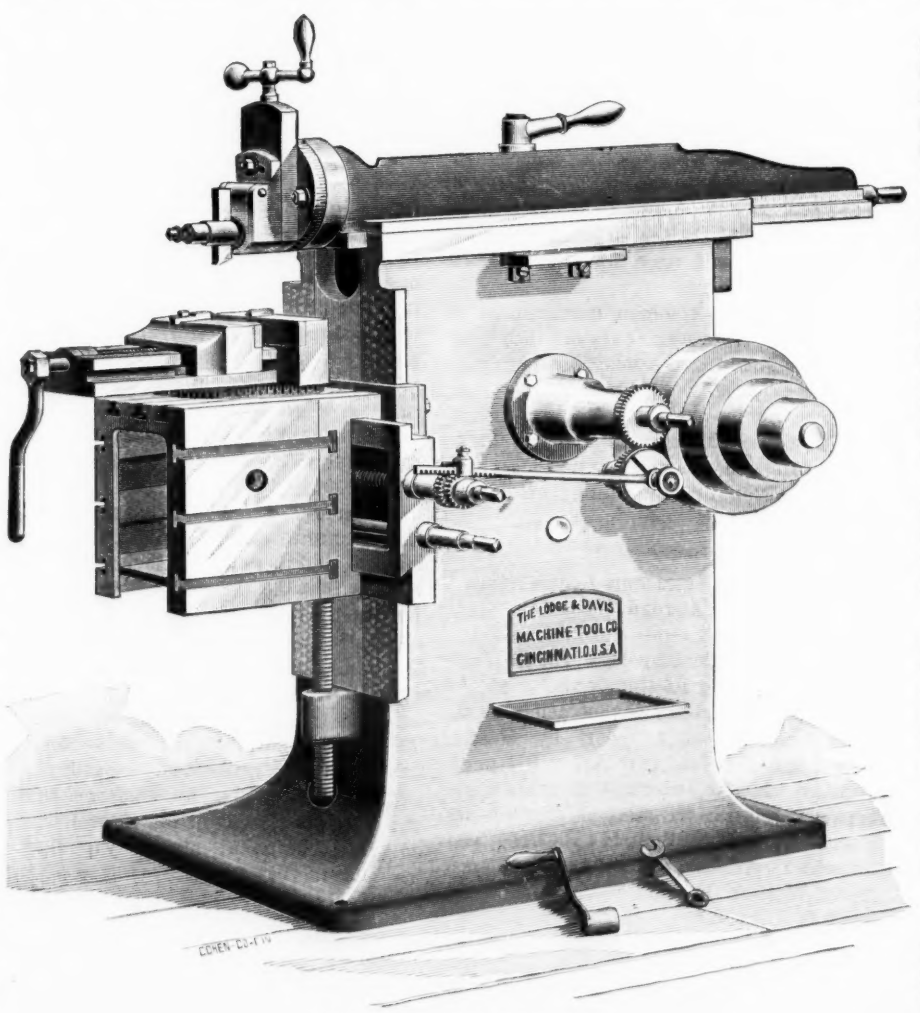


GEAR CUTTERS.

Regarding the stress allowed on driving ropes, it may be of interest to note that one of the largest builders of mill engines in Lancashire (England) tried the experiment, a few years ago, of using fewer ropes to transmit a given amount of power than had hitherto been allowed. They soon discovered that they had made a mistake, however, and have long since reverted to their former practice in this respect.

Some experiments on rope and belts, made by M. Fanquier, have recently been much commented upon, as the results obtained do not favor the use of rope gear. It appears to me that in the particular installation referred to as an "actual case," good results could scarcely have been expected from ropes The engine was developing 216 horse power at the time of the test, and six ropes $1\frac{9}{16}$ inches in diameter were used to transmit the power to a dynamo. The driving pulley was 18 feet in diameter and the dynamo pulley $34\frac{1}{2}$ inches. The ropes were of manila, and were stated to have been "well made and pliable." Regarding the stress per rope, it may be said that for ordinary circumstances, 36 horse-power per rope at the speed employed, was quite satisfactory. But with a driven pulley only two-thirds the minimum size allowable for the more pliable *cotton* rope, the loss of power was doubtless considerable. In this particular case, it was found that 11 6 horse-power was lost in the power transmission, or about 5.4 per cent. For some reason, which is not easy to imagine, the maker of the ropes attempted to reduce this loss by using *larger* ropes of $2\frac{5}{8}$ inches diameter. As might have been anticipated, this resulted in a far greater loss of power, not less than 23.5 horse power being absorbed, or more than double that lost by using the small ropes. Such experiments are of little value in determining the efficiency of properly designed rope gear, but they serve to show how materially the efficiency of the installation can be affected by ignoring the teaching of good practice.

M. E.



FOURTEEN-INCH SHAPER.

Gear Cutting by Gang Cutters.

We illustrate herewith a form of gear tooth cutter which is being introduced by Gould & Eberhardt, of Newark, N. J., in connection with their automatic gear cutting machines, the latest form of which machine we illustrated and described in our issue of April 5th.

Though various mechanics have declared that such cutters could not be made to work satisfactorily, yet they are used with entire satisfaction for certain classes of gears, and, of course, will cut gears very rapidly when used in a machine of sufficient power and strength.

To make them work well, it is necessary only to so shape them to a gauge that they will produce the proper form of tooth properly spaced, and the indexing on the machine can then be for two or more teeth at each cut, instead of only one.

Each cutter is, however, made separately and "patent relieved," so that it can be ground upon the faces of its teeth without alteration of shape.

With this system, 10 inches to 40 inches of cutting per minute is possible, and cut gears can be produced as cheaply as cast ones.

Improved Fourteen-Inch Shaper.

The accompanying illustration represents an improved 14-inch shaper recently brought out by The Lodge & Davis Machine Tool Co., of Cincinnati, Ohio.

The movement and quick return of the ram is obtained by the usual slotted vibrating arm which holds in its upper end a roller working in a slot formed in a nut, sliding in a suitable bearing upon the under surface of the ram. This nut can be adjusted by means of the screw shown at the rear end of the ram, while the machine is running, setting the ram to any desired position.

The adjustment, for the length of the stroke of the ram, is made by a shaft protruding out of the feed wheel stand, operating, by means of a pair of bevel wheels, the crank pin holding screw. This adjustment is also made while the machine is in motion, and does not necessitate any locking of these parts.

The rack, moving the feed pinion on the table feed screw, is so supported and of such a length as to require no adjustment whatever when the cross-rail is moved up and down.

The squared shaft at the right of the cross-rail below the cross-feed screw operates the elevating screw, and the same crank fits all adjusting shafts. The down-feed screw for the tool block, and the table feed screw are indexed by an adjustable collar.

The table is detachable and the cross-rail and screw arranged for the direct application of the circular planing attachment.

It is said that there is talk of the Navy Department going into the business of making its own steel castings, the reason for this being, as alleged, that it is practically impossible to get sound castings from contractors; that as many as 45 per cent. of the castings furnished are rejected on account of defects after considerable work has been done on them by the department.

A press dispatch announces the death, at Kansas City, of Joseph Lewis, who was junior member of the firm of Lewis & Sons, in Manchester, England, where George Stevenson's engine was built in 1829. Mr Lewis came to this country some years ago, and died at the home of his nephew, Chas. Cookson, of the Cookson Iron Works.

AMERICAN MACHINIST

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☞ *We invite correspondence from practical machinists, engineers, inventors, draftsmen, and all those specially interested in the occupations we represent, on subjects pertaining to machinery.*

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NEW YORK, DECEMBER 6, 1894.

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Look to the Boiler room.

The enormous coal consumption per unit of output in many electric lighting and power plants is cause for general comment, especially since a recent committee report brought the wide variations of efficiency prominently into notice.

Theories innumerable are advanced to account for the difference between the fuel burned per horse-power in driving the dynamos, as compared with other service; a favorite conclusion seeming to be that compound engines are not satisfactory when working through other than narrow ranges of power variation.

While this is probably true of a great many of the engines used for such work where the cylinder proportions and general make-up are no credit to those responsible for the designs, yet there is little doubt but that one main cause of the trouble must be looked for in another direction. A glance through the power houses discloses the fact that many of them are run on an easy-going basis, no attempt seemingly being made to maintain proper discipline among the attendants, each of whom shifts for himself without let or hindrance from the directing authority.

A genuine fireman, thoroughly trained in the principles of his profession, would blush with shame at sight of these boiler departments.

In place of clean grates, giving a bright glow beneath, the bars are masked by clinker, and the ash pits yawn without a ray of light to show what is going on within.

The air wheezes as it forces a passage through the refuse, instead of passing in with that rustling sound that tells of free combustion.

At infrequent intervals, between the discussion of politics, or other matter foreign to the work in hand, an individual, whose only claim to being a fireman lies in his ability to heave carbon against the back of the furnace, rises from an ottoman of coal and canvas, and throwing open a furnace door, leisurely proceeds to shovel in a half ton or so of fuel, after which work of art, with no attempt to level the fire, or clear the grate, he throws himself upon his couch for another restful season.

Under the too common management of such places, there seems to be not the slightest incentive offered a man to properly attend his boilers.

An enormous grate and heating surface, and immense chimney, are relied upon to maintain steam, when a few first class men at the fires would make fewer boilers do better work.

English and American Locomotives Abroad.

Our London contemporary *The Engineer* is again launching its thunder-bolts at the American locomotive; the occasion of its latest attack being a report by Messrs. Elordi and Esteves, two Argentine engineers, in which report comparisons are made between English locomotives running on Buenos Ayres Great Southern Railroad, and American locomotives running on the Buenos Ayres Western Railroad; both these roads being in Argentina.

The report, which is made up evidently upon a basis of actual experience with the engines, is very favorable to the Baldwin machines, and our contemporary is moved to remark regarding it that:

It is altogether damaging to the English engines; altogether in favor of the American locomotive, and in every way curious reading, exemplifying as it does the methods by which engines built in the United States are pushed into favor without any special regard for the facts.

This is severe, of course, but it is amply justified by what these prejudiced Armenian (not Yankee this time) engineers say in their report. For instance, they say, in speaking of the English engines, that:

"The builders did not take into account the character of the road-bed and track on which the engines had to run, and therefore made them too heavy and the wheel-base too rigid."

In reply to this *The Engineer* says:

"This is, of course, the old, old story. The English engine is too good for the roads, or the country, or the climate. If only it was worse it would give more satisfaction."

By which it is seen that our contemporary still believes that American locomotives are successful, not so much because they are better adapted to the service they have to perform, as because they are intrinsically inferior to the English machines, which, however, in this case are declared by these Argentine engineers to be "but iron masses, entirely injurious to the roads and interests of the company," which, of course, will be at once recognized by all readers of *The Engineer* as nothing but "Yankee brag and bounce."

So far as we can see, the only point of importance which our contemporary makes regarding the report is to the effect that the English engines in question have really been modified from the usual English practice, so that they strongly resemble the American engines, and so cannot be so much worse than they.

Command of Naval Vessels.

We publish elsewhere in this issue a letter from a man (now connected with a manufacturing establishment) who had some experience on board naval vessels during the war, and who, though he is somewhat sarcastic, perhaps, yet writes an interesting letter, and makes out a very good case from his standpoint.

We think, however, that this gentleman misses the point of our argument. No sane man, we think, would for a moment think of denying that the captain of a naval vessel must command the vessel. He is responsible for what the vessel does, and his control should be commensurate with his responsibility. But by the same token, the control of the engineer should be commensurate with *his* responsibility, and he should be and must eventually be freed from the annoyance of constant interference with details about which the officer interfering can, in the nature of things, know nothing whatever.

Any one who knows anything of industrial affairs knows that foremen of departments, for instance, must not be continually interfered with as to the management of details connected with their work. Such a practice is fatal to the efficient conduct of affairs, and when a superintendent makes a practice of changing men about or giving them direct orders without the knowledge of their foremen, it is time for some change of "personnel."

No amount of sophistry can ever make of the "Danforth case" anything else than an outrage, and there is abundance of evidence to show that the line officers are trying by just such arguments as that presented by our correspondent, "Forecastle," to keep the administration of affairs in the navy upon the same basis as they were fifty years ago, when conditions were entirely different. There can be but one ending to this, and eventually, many, if not all, the points now being contended for by engineer officers will be gained; but in the meantime, and notwithstanding the gentlemanly qualities of line officers, they are occupying and probably will occupy the position of reactionists.

Since the publication of our remarks about the apparent advantages of an international postage stamp to carry mail matter between any two countries of the Postal Union, we have received from Henry C. Morris, U. S. Consul at Ghent, Belgium, a letter, in which he refers to the importance of the proposed innovation, and says he has seen a report to the effect that the Minister of Posts, of Germany, has been designing such a stamp, and will soon submit it to the other members of the Union.

It gives us pleasure to make such an announcement, and we shall hope the time is not far distant when a series of universal international postage stamps will be on sale at all post offices where they are at all likely to be called for.

Literary Notes.

ELECTRICITY AT THE COLUMBIAN EXPOSITION. By J. B. Barrett, Chief of Department.

In this book all the electrical exhibits and their features, which seemed to the author worthy of consideration, are described, and many of them illustrated; the more important ones are dwelt upon at some length, and others are dismissed with bare facts, the whole forming a reminder of what the visitor saw, given in a most entertaining and interesting style.

The illustrations are of the highest character made from the best kind of photographs. Those interested in the progress of the science of electricity, and wishing to possess reliable information as to what was shown in the electrical line at the Columbian Exposition, cannot do better than to obtain a copy of this work. It is published by R. R. Donnelley & Sons, Chicago, Ill. Price, $2 50.

THE MEASUREMENT AND DIVISION OF WATER. By L. G. Carpenter.

This pamphlet of 42 pages treats on the measurement and division of water used for the purpose of irrigation, and describes the methods which should and which should not be used. The author states: "In passing over the lines of ditches in Colorado and in other States, and in other countries, I have made their methods a special object of observation and inquiry. In general, it may be said that the prevailing methods are exceedingly unreliable. In some canals, even the large ones, there is little attempt save by eye or the judgment of the ditch rider; in others, there are nominal measures which frequently are worse than none at all, because while giving no approach to a proper measurement, they give among the consumers and canal officers a false sense of accuracy, and stand in the way of a better system. In others, the systems are as good as the present conditions will permit. When water has been plentiful in the streams, there has been no necessity for close division or measurement, for there has been water enough to supply the demands of all. But with the greater demand for water and the need by each farmer of every drop obtainable, there is greater necessity for closer measurement, and many canal organizations are being led to consider more efficient means of measurement and distribution."

Those who are interested in problems of irrigation will find much valuable matter in this pamphlet, and should procure a copy. It is sent to all residents in Colorado interested in any branch of agriculture free of charge; non-residents, upon application, can secure copies by writing to the Director of the Experiment Station, Fort Collins, Colorado.

Questions and Answers.

Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.

(551) J. C. W., Buffalo, N. Y., writes: Kindly inform me what numbers of your publication treat on the process of making blue prints, and the necessary apparatus and methods of getting the best results. *A.*—See answer to Question 120, in our issue of March 8, 1894.

(552) H. M. C., ——, asks: 1. Which is the strongest, a steel or a gray iron casting, for instance, for such a purpose as the jaw for a Prentiss vise? *A.*—Strictly speaking, it depends a good deal upon what the castings are; in other words, we think that some gray iron castings are stronger than some steel castings, but generally speaking, and in the ordinarily accepted sense of the terms, the steel castings should be the strongest. 2. What is the actual amount in cents (American money) of an English shilling? *A.*—We believe the exact equivalent is 24 cents, $3\frac{1}{3}$ mills. It is usually called 25 cents.

(553) B. C. M., Battle Creek, Mich., writes: To settle a dispute kindly answer the following: 1. Will a piece of iron 4 inches square sink to the bottom of the ocean in its deepest part? *A.*—Yes. 2. If so please give a reason for it. It is claimed that at some depth its weight will be counterbalanced by the upward pressure of the water, and, therefore, it will become a floating particle in the ocean. *A.*—Your argument is not correct, because you overlook the fact that although the pressure on the bottom of the iron increases, the pressure on top also increases as the depth of immersion becomes greater. The buoyant effort is equal in amount to the weight of the liquid displaced, and this remains the same for all depths of immersion.

(554) W. B. H., Chicago, Ill., asks: Is there any way of annealing mica so that it may be bent back and forth without cracking? *A.*—We do not know of any such process. 2 Is there a cement or glue that will stick mica and cloth firmly together? *A.*—To any quantity of glue use common whiskey instead of water. Put both together in a bottle corked tight and set it for 3 or 4 days, when it will be fit for use without the application of heat. Glue thus prepared will keep for years, and is at all times fit for use, except in very cold weather, when it should be set in warm water before using. To obviate the difficulty of the stopper getting tight by the glue drying in the mouth of the vessel, use a tin vessel with a cover fitting tight on the outside, to prevent the escape of the spirit by evaporation. A strong solution of isinglass made in the same manner will also answer the same purpose, and is an excellent cement for leather.

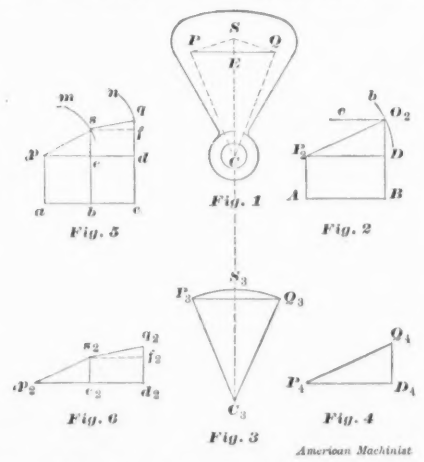
(555) Lacey, Philadelphia, writes us: I have had considerable trouble in drilling small holes (No. 30) in tool steel ¼ inch thick. I would like to ask which is the best kind of drill to use, what is the best speed, and what is the best liquid to use on the drill? *A.*—We should use the best twist drills. We *guess* that your "No. 30" is about ⅛" diameter, and if so, we should run them at a speed of about 500 revolutions; lard oil may be used, and is a good liquid for the purpose, but the preparation, a formula for which is given in answer to Question No. 495, in issue of October 25th, may also give good satisfaction. 2 Is there any means for annealing tool steel to make it softer and easier to drill than when it comes from the warehouse? I have no stove or oven, nothing but an open fire to do any annealing that may be suggested. I would much rather use the stock direct from the bar, if by any means I can get over the difficulty of drilling it. *A.*—Most manufacturers of steel now furnish it in annealed bars. We should advise that you get these, and you will probably have no further trouble.

(556) J. J. H., Cleveland, Ohio, writes: In looking over the Hartford Insurance specifications for steam boilers, I noticed the requirements of steel boiler plates ⅝ inch thick to be 55,000 to 65,000 pounds tensile strength, ductility 56 per cent. at point of fracture, and the elongation 25 per cent. in a length of 8 inches. I would like to ask you if the above are government requirements; if not please publish them in your columns. *A.*—The requirements, given in the rules and regulations prescribed by the Board of Supervising Inspectors of Steam Vessels, read as follows: To ascertain the tensile strength of plates, a piece shall be taken from each sheet to be tested, the area of which shall equal one-quarter of one square inch on all plates $\frac{5}{16}$ inch thick and under; and all plates over $\frac{5}{16}$ inch thick the area shall be equal the square of its thickness; and the force at which the piece can be parted in the direction of the fiber or grain, represented in pounds avoirdupois—the former multiplied by four, the latter in proportion to the ratio of its area—shall be deemed the tensile strength per square inch of the plate from which the sample was taken; and should the tensile strength ascertained by the test be equal to that marked on the plates from which the test pieces were taken the plates must be allowed to be used in the construction of marine boilers; provided always, that the plates possess homogeneousness, toughness, and ability to withstand the effect of repeated heating and cooling; but should these tests prove the plates overstamped, the lots from which the test plates were taken must be rejected as failing to have the strength stamped thereon. But nothing herein shall be so construed as to prevent the manufacturers from restamping such plates at the lowest tensile strength indicated by the samples, provided such restamping is done previous to the use of plates in the manufacture of marine boilers. To ascertain the ductility and other lawful qualities, iron of 45 000 pounds tensile strength, and under, shall show a contraction of area of 15 per cent., and each additional 1 000 pounds tensile strength shall show 1 per cent. additional contraction of area, up to and including 55,000 tensile strength. Iron of 55,000 tensile strength and upwards showing 25 per cent. reduction of area, shall be deemed to have the lawful ductility. All steel plates of ¼ inch thickness and under shall show a contraction of area of not less than 50 per cent. Steel plates over ¼ inch in thickness shall show a reduction of not less than 45 per cent. Provided, however, that steel plates required for repairs to boilers built previous to April 1, 1886, may be used for such repairs when showing a contraction of area not less than 40 per cent.

(557) H A., St. Louis, Mo., writes: Kindly inform me as to the correctness of the following: 1. Referring to centrifugal pumps: Is the total head equal to the suction head plus velocity, plus delivery head? *A.*—This is not quite correct; to the above sum the friction head should be added. 2. Is the effective horse power equal to the weight of water discharged per second multiplied by total head, and the product divided by 550? *A.*—No; we understand the effective horse-power to be the power required to raise the weight of water which is discharged from the lower water level to the center of discharge nozzle; this distance is, of course, equal to the suction head, plus the delivery head; hence the effective horse power is equal to the weight of water in pounds discharged per second, multiplied by the sum of the suction head and delivery head in feet, and the product divided by 550. 3. Is the efficiency of the pump equal to the effective horse power, divided by the indicated horse power? *A.*—No. The efficiency of all machines is found by dividing the useful work done by the total work expended in doing this work. If the pump is simply used for raising water, then the useful work done per second is equal to the effective horse-power; hence, to find the efficiency of the pump, divide the effective horse power by the horse-power required to drive the pump, and not by the indicated horse-power of the engine, as this will include the power required to drive the engine itself. 4. Where can I obtain data of tests relating to the efficiency of these pumps? *A.*—Data of this kind is very scarce; we cannot call to mind at present where it can be obtained. 5. Give me some simple methods of testing cast-iron, wrought iron and steel, and give title of a book treating on this subject. *A.*—The simplest, and, at the same time, probably the most satisfactory test of iron and soft steel, particularly when these materials are to be used for boilers, is to shear off a strip of any convenient width, say, one to two inches, and bend it down cold with a sledge hammer until the ends of the strip touch each other. It is the practice of all reputable manufacturers to reject any plate $\frac{5}{16}$ inch thick and less which will not stand this test without breaking. The temper test for steel consists in shearing a strip from a plate, and heating it to a low cherry red heat, and suddenly quenching in water, allowing it to remain there until cold, and then bending the sample over double until the diameter of the inner curve is from two to three times the thickness of the plate, without exhibiting any signs of fracture. The drifting test consists in shearing samples 2½ inches wide, and punching a ⅝ hole in the center, annealing thoroughly and drifting the hole out with taper pins. The larger the hole the better the material; it is expected that ordinary steel plates will drift to twice the diameter of the punch without any signs of fracture. For other tests, including those of cast iron, we have to refer you to "Strength of Materials and Structures," by John Anderson, published by Longmans, Green & Co., 15 East Sixteenth street, New York.

(558) W. K. H., Kansas City, Mo., writes: Kindly give formula for computing the horse-power of a boiler according to the Centennial standard; also according to the standard of American Society of Mechanical Engineers. *A.*—The committee of judges of the Centennial Exhibition adopted for all standard trials for a commercial horse-power an evaporation of 30 pounds of water per hour from feed water at a temperature of 100° Fahr. into dry steam at 70 pounds gauge pressure per square inch. The standard adopted by the American Society of Mechanical Engineers gives practically the same results. This standard is 34½ pounds of water evaporated from a feed water temperature of 212° Fahr. into steam at the same temperature. This standard is computed from the Centennial standard as follows: The quantity of heat demanded to evaporate a pound of water from a feed water temperature of 100° Fahr. into steam of 70 pounds gauge pressure is 1.110 2 British thermal units, hence, for 30 pounds of water, $30 \times 1{,}110.2 = 33.306$ heat units per horse-power are required. To evaporate one pound of water from and at 212° Fahr., requires 965 7 heat units, hence, 33.306 divided by $965.7 = 34\ 48$ pounds of water, practically 34 5 pounds of water evaporated per hour at and from 212° Fahr. will be required per horse power. To show how the horse power of a boiler can be computed from the above standards we shall take the following example: A boiler evaporates 3,000 pounds of water per hour under a gauge pressure of 120 pounds, the temperature of the feed water is 80 degrees; compute the horse-power of the boiler. The feed water at a temperature of 80 degrees contains 80 units of heat (this is not quite correct, but is sufficiently close for ordinary purposes). The number of heat units in a pound of steam under an absolute pressure of $120 + 15 = 135$ pounds is 1,220.7; subtracting the heat units of the feed water we have $1{,}220\ 7 - 80 = 1{,}140\ 7$ heat units which are demanded for the evaporation of one pound of water into steam of the required pressure, and to evaporate 3 000 pounds of water we require $1{,}140\ 7 \times 3\ 000 = 3{,}422{,}100$ heat units. We have seen that 965 7 heat units are required to evaporate one pound of water from and at 212 degrees, hence the number of heat units as found above will evaporate $\frac{3\ 422{,}100}{965.7} = 3{,}543\ 6$ pounds of water per hour from and at 212 degrees. But 34.5 pounds of water evaporated per hour under the above conditions is one horse-power, hence according to the standard of the American Society of Mechanical Engineers the boiler is rated at $\frac{3543.6}{34\ 5} = 102.71$ horse-power. We have seen that according to the Centennial Standard 33 306 heat units per horse-power per hour must be expended, and in the boiler given in the example we have computed that 3 422 100 heat units have been expended per hour, hence, according to the Centennial standard, the horse-power of the boiler will be rated at $\frac{3.422\ 100}{33,306} = 102.74$. The units of heat in one pound of steam under a given pressure is found in steam tables given in all books treating on steam.

(559) X. Y., New York, writes: Please give me some simple rule for determining the pitch of a propeller wheel, such as can be used in selecting from a number of patterns the wheel required. *A.*—Set off on the face of the blade any two points P and Q at equal distances from the center C as shown in Fig. 1, and measure on the face of the blade the chord distance $P\ Q$ between these points. In Fig. 2 draw a horizontal line $A\ B$, and at A erect a perpendicular line, and make the distance $A\ P_2$ equal to the distance between the point P (Fig. 1) and a straight edge laid on the face of the hub. From P_2 as a center, and with a radius equal to $P\ Q$ (as measured on the face of the blade), draw an arc b then draw the horizontal line $c\ Q_2$ intersecting the arc b in the point Q_2; the distance between $c\ Q_2$ and the line $A\ B$ must be equal to the distance from the point Q to a straight edge laid on the face of the hub. Through P_2 draw a horizontal line $P_2\ D$ and thus obtain the difference in height between the two points P_2 and Q_2 from the horizontal $A\ B$. From any point C as a center and with a radius equal to $C\ P$ (Fig. 1) draw an arc $P_3\ S_3$, Q_3 in Fig 3, and makes its chord $P_3\ Q_3$ equal to $A\ B$ in Fig. 2; measure the length of this arc, and make the horizontal $P_4\ D_4$ in Fig. 4 equal to it; at the extremity D_4 erect the perpendicular $D_4\ Q_4$ equal to $D\ Q_2$ in Fig. 2. Now the pitch of propeller is found by the following proportion: The line $P_4\ D_4$ is to $D_4\ Q_4$ as the circumference of the circle described with a radius $C\ P$ is to the pitch of the propeller. If, for instance, we find by measurement that the length of $P_4\ Q_4$ is 8 inches, $D_4\ Q_4 = 4$ inches, and the radius $C\ P = 7$ inches, the correspondent circumference being 43.9 inches, we have



$$8 : 4 : : 43.9 : \text{pitch};$$

from this we have:

$$\frac{4 \times 43\ 9}{8} = 21.95 \text{ inches pitch.}$$

The above is applicable to a true screw, and not to screw with expanding pitch. If the screw has an expanding pitch, we must set off on the face of the blade three points P, S and Q (Fig. 1) at equal distances from the center C, and then proceed as follows: Draw any horizontal line $a\ c$. Fig. 5; and above this line draw horizontal lines at distances $a\ p$, $b\ s$, and $c\ q$, respectively equal to the measured distances from the points P, S, and Q to the straight edge laid on face of the hub. From any point p on the line $p\ d$ as a center, and with a radius equal to $P\ S$, describe an arc m cutting horizontal $s\ f$ in the point s; and from s as a center with a radius equal to $S\ Q$, describe an arc n cutting the upper horizontal in the point q. In Fig. 6 make $p_2\ e_2$ on the horizontal line equal to the length of the arc $P_2\ S_2$, in Fig. 3; and $e_2\ d_2$ equal to the length of the arc $S_3\ Q_3$; also make $s_2\ e_2$, in Fig. 6, equal to $s\ e$, in Fig. 5, and $d_2\ q_2$ equal to $d\ q$; and draw the horizontal $s_2\ f_2$. Now, to find the pitch on the left hand side of Fig. 6, we have: $P_2\ e_2$ is to $e_2\ s_2$ as the whole circumference of the circle drawn with a radius equal to $C\ P$ is to the pitch. And for the left-hand side of Fig 6, we have $s_2\ f_2$ is to $f_2\ q_2$ as the whole circumference is to the pitch. The last method is a close approximation only, but will answer all ordinary practical requirements.

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Notes on Steel Forgings.*

BY G. M. SINCLAIR, PHILADELPHIA, PA.

The closing decades of the nineteenth century have seen wrought iron practically driven out of our markets and supplanted by steel. So rapid has been this change that many users, and even producers, have not thoroughly grasped the distinguishing characteristics of the latter metal and their influence, and the extension of the use of steel, rapid as it has been, has been somewhat retarded by costly errors due to this very cause.

We purpose to note some of the general principles controlling the manufacture and use of steel forgings. A forging may be good or bad, independent of its material, so that we shall avoid metallurgical questions,

*Presented at the New York meeting (December, 1894) of the American Society of Mechanical Engineers.

and take only what may be called the mechanical view of this subject. This will exclude questions of composition and many other interesting and important subjects. By "steel," the ordinary carbon steel is referred to, although the statements made apply with equal force to many or all of the numerous other varieties.

The first point to be considered is the design of the forging. Iron forgings are essentially built up so that it follows that great irregularities of shape are of small moment, so far as the manufacture is concerned. A steel forging, on the other hand, is made from an ingot, which at the outset must be sufficiently large in section to make the largest part of the desired forging out of it. It cannot be enlarged in section except in minor cases, when it may be upset or have a piece welded on. But it is highly objectionable to weld in steel, especially where any strain is put on the weld; and with some grades of steel, welds are altogether out of the question, and even with soft steels, they are undesirable. Cases may be met with, however, in which it is desired to fill out a forging at a point where no stress of importance will come, as, for instance, to form a boss to carry an oil cup, when a piece of iron or soft steel may be "jumped" on in preference to making a set-down. As a rule, however, avoid all welds. The designer must remember the conditions, which are mainly these: An ingot of practically uniform section to start with, and a material which demands as few heats as possible and does not permit of welds. It follows that he must make his design as simple and uniform as possible, avoiding large collars, arms, sharp set downs, and other irregularities of form. In return he will get a forging which has been finished in a few heats, at low cost, accurate to size, and giving the machine shop a minimum of work.

The design completed and furnished to the forge master, the billet or ingot is selected, and goes into the heating furnace. What is the condition of an ingot? After being cast it has cooled rapidly from the outside. Since the heat of the interior has passed off through the outer portions of the mass, the interior has necessarily been at a higher temperature than the surface during the entire cooling process, and the more rapid the cooling the greater the difference of temperature between the exterior and interior. The surface has finally set rigidly while the interior was plastic or even fluid. While the interior was still fluid the shrinkage at the lower portion of the ingot is fed from above. Frequently this is at the expense of a hole, or "pipe," at the upper end; but even if the ingot when cooled is solid throughout, the metal is under stress. It is as if a quantity of steel were put in a rigid shell too big for it, and were stretched out in all directions to fill it. Now suppose this rigid shell is expanded by heat so quickly that the heat is not transmitted in any appreciable amount to the interior. It follows that this interior portion must immediately stretch more in every direction, or it will not fill the interior of the shell. So the interior of an ingot is under stress when put into a heating furnace, and these stresses are increased as its exterior is expanded. If the heating is not done slowly, so that before much additional stress is induced, the interior has acquired heat and begun to expand, and the whole ingot is thus gradually brought to a plastic condition, there may be internal cracks in the ingot when it goes to the forge. This danger is not great with small ingots, but large ingots will sometimes crack with a noise like a bell while still almost cold.

To heat slowly, and at the same time economically, requires careful consideration in designing the furnace. Some furnaces under favorable conditions will heat ten pounds or even more for one pound of fuel. There are other furnaces in use which do not do better than pound per pound. If very large pieces are to be heated, requiring high temperatures for a long time, the regenerative form of furnace will effect great economy of fuel. If, on the other hand, a great number of small pieces are handled, the furnace might be made long, and the work passed gradually from the cool end to the hot end. This is a form of continuous furnace with many advantages, but with any furnace, however, a mild, reducing flame must be kept to avoid "burns" and scaling. The ideal way of heating is to reverse the operation of cooling, that is, heat from the inside outwards. With present appliances this is not possible, except with bored ingots, which are only used for hollow forgings. Perhaps our electrical friends will perfect a system by which, for example, we shall wrap an ingot in asbestos, run two poles up against the ends, turn a switch, and find our ingot heating rapidly, safely, and with almost no loss from scaling. In such a system the expense of a furnace would be offset by that of boilers, engines and dynamos, but it would be rash to say that this may not be the method of the future, even for large work. This operation of heating is the first one which the forge undertakes, and is one where, in the majority of cases, a considerable saving could be effected. The requisites for that object are, primarily, a well-designed and constructed furnace, and, secondarily, intelligence in using it. No fixed rules can be given to fit all cases, but each must be carefully studied.

In the manufacture of a forging, the forging process itself furnishes the most obvious field for introducing economies and safeguards, and has, therefore, probably received most attention. To change the form of a mass, there must be a flowing of particles over one another against a certain amount of resistance. Time is an essential factor of this flowing. In making a forging, therefore, we have a force acting through space during time, and all three factors, the force, the space, and the time, are variable. Bearing in mind these general considerations, a few words on the relative merits of the steam hammer and the hydraulic forging press will not be out of place. The action of the hammer differs from that of the press mainly in the time effect of the blow. Suppose a similar blow from the two machines, that is, the same area and mass of metal deformed to the same extent. Then, in the case of the hammer, the inertia of the falling mass is absorbed by the metal in a very short time, in which the velocity is reduced from the maximum to nothing. For our comparison, take that type of press in which the pumps deliver water to the cylinder. There we have the falling weight of the hammer paralleled by a revolving fly-wheel, and the steam in the cylinders of the engines acting during the blow, would correspond to top steam in the hammer. The "work" in the press, however, would not absorb the entire energy of the fly-wheel, for, of course, the water will be shut off before the engines are stopped. The duration of the blow is greatly lengthened, and the velocity of the die is much less than that of the fly-wheel; but, as in the hammer, there is a retardation from the time the die touches the metal until the deformation is completed. The nearer the blow to the capacity of the press, the greater the retardation, and the farther from that limit, the more nearly uniform the velocity of the blow. In fact, the hammer becomes a press when the trip is so heavy that it does its work without any fall, and the press would be a hammer in effect, if the stored energy of the fly wheel were transmitted so directly as to be absorbed in the same time as the energy of the falling trip of the hammer. While such construction is impractical, the illustration shows that within limits the two systems do approach each other in every day, practical work. To sum up, it may be said the press differs from the hammer in that, by the intermediary of water, and the enlargement of the water passage at the cylinder of the press, we retard the blow, and extend its effect over a much greater time.

This being the difference of action of the two systems, which will give a better product? Theoretically, under the press, the particles having ample time to flow, the treatment is not so severe. Practically, however, under a hammer properly proportioned to the work, the particles have then likewise "ample time" to flow. In other words, the press takes a needlessly long time to effect the deformation. Of course, we refer only to steel. Other materials may require all the time, or even more, for deformation, which they would have under the press as now constructed. But for steel, the product of the hammer is equal, if not superior, in quality to that of the press. There is, however, a chance for bad practice in the use of hammers which does not exist with presses. A light hammer driven at a high velocity expends its energy on the surface of the forging. The interior not only is not compacted and worked, but it is actually opened up, and even ruptured. While hammer forgings can be so made, and may in use have, or soon develop, bad internal cracks, with the press this is impossible, and this fact is a guarantee, to a certain extent, to justify the use of hydraulic pressed forgings.

It is the distinction in the operation of light and heavy hammers, above noted, which has given rise to the prejudice often found against top steam. This prejudice has little foundation, and it would be a mistake to build a hammer for general forging purposes without it. It is the unfortunate property of all steam hammers that the larger the forging, and, therefore, the greater the power required, the less power is there available, since the large size of the forging reduces the stroke of the hammer. Top steam enables the hammer in effect to lengthen its stroke. That is, it will give the tup at part stroke the same velocity that it would acquire by gravity at full stroke. This gives the hammer vastly greater range without necessarily trespassing on the forbidden ground of high velocities. Further, it increases the product, for a greater number of blows can be given in the same time than with a hammer actuated only by gravity. The use of top steam is legitimate; its abuse must be guarded against.

The advantages of the press over the hammer rest chiefly on merits appealing to the manufacturer of forgings. Except for some varieties of plain work the best designed presses are quicker than hammers, their running expenses are less, and, above all, owing to the absence of shock, they are much more *mechanical* tools, forgings being turned out from them with precision and ease, which could not possibly be made at a hammer. These advantages can scarcely be overestimated. Perhaps the severest criticism brought against the press is the comparatively high heat at which forgings are finished. As all forgings are or should be annealed before being put into use, this criticism has little force.

Whether the forging is made by a press or by a hammer, the virtues or faults of the design must be considered by the hammer man. Before beginning work he must plan it. All reheating and specially reheating of finished parts must be avoided. It is time well spent to think out every operation beforehand, to have dimensions calculated, and templates prepared for various critical points of the manufacture, and, in short, so to prepare that almost any contingency which may arise has been foreseen. When a piece is heated and brought to the hammer or press, there is no time for deliberations and consultations. If they become necessay, it is at the expense of the economy and quality of the work.

The forging being made, it remains to "treat" it. The usual treatment is annealing or oil tempering and annealing. Exactly what takes place in a piece of steel submitted to these processes is not certainly known, but the physical results are pretty well understood. In most cases the treatment will consist only of annealing. Formerly the annealing process was a very perfunctory operation, and frequently was omitted altogether. To-day it is generally and rightly regarded as important. All steel comes from the hammer or press with internal stresses more or less severe. The particles are in a disturbed condition, and cannot adjust themselves while the metal is cold; at least, not in a reasonable time. Annealing relieves these stresses. It will also break up crystallization more or less effectively. The effect of annealing is shown by the testing machine by a reduction in tensile strength and increase in extension. To anneal properly, furnaces for the purpose should be used. The old method of burying in lime or ashes, though beneficial, is uncertain and incapable of accurate results. The design of the annealing furnace, like the heating furnace, is capable of much variation, and for best results must be made to suit the peculiarities of each case. The fuel may be wood, coal, gas, or oil. The essential characteristics are, that it shall enable the work being treated to be brought up to any desired temperature slowly and uniformly, and again cooled in the same manner. With these two points provided for, all other devices and arrangements of furnace for facilitating work and for economy may be introduced. For high-class work, the temperatures of the furnace, composition of the metal, and physical tests must be noted. In fact, no one at this time can hope to compete for high-grade work without the free use of the chemical laboratory and testing machine, and making and preserving more or less elaborate records.

There is a great variety of other processes by which forgings may be treated, such as case hardening, Harveyizing, hardening in water, oil tempering, etc.; but the last mentioned is of more general applicability than any of the others, and we shall close by a reference to it. Its most obvious effect on steels having a moderate percentage of carbon seems to be of a physical character analogous to forging. The sudden contraction due to the chilling of the surface compacts the metal and breaks up crystallization. At the same time the suddenness of the cooling in itself has a tendency to check or prevent the formation of crystals. It is evident from the above, and also from experience, that the thicker the metal the less will be the effect of the oil tempering, and at no very great thickness the metal in the interior will be little affected. It is also evident that for very irregular shapes the process is not applicable. For cylindrical pieces, and especially for hollow cylinders, it is a most beneficial operation. A coarse crystalline structure is readily changed to a fine homogeneous quality. The most marked effect of oil tempering and annealing on steel is the raising of the elastic limit. This is accompanied by a moderate gain in tensile strength and a slight loss in ductility; but both these results are secondary in importance, and amount to the effect on the elastic limit. "Gain" and "loss" above are taken with reference to the same steel thoroughly annealed, but not oil tempered, and also it is to be noted that oil tempering should, except in particular cases, be followed by annealing.

The application of this treatment is now universally adopted for gun forgings, and has extended from that to large shafting and similar work, and is now also used for armor plate. The details of tempering, whether double or single, at what temperature, etc, depend on circumstances. In general, the plant necessary consists of a furnace for heating, capable of giving the forging a high uniform temperature, a tank of oil, and proper hoisting and conveying machinery to pass the work quickly from the furnace to the tank. It is to be noted that the heating in this case is of an intermittent character, and the furnace will be designed with that in view. Oil tempering opens the way for a bad practice which is not always avoided as it should be, and, in fact, is not always recognized as such. We refer to the selection of a very soft steel for the forging and tempering up to fill specifications. This is sometimes carried to such an extent that the final annealing is so slight as to be a farce. While oil tempering benefits the metal, it leaves it with considerable internal stress which should be relieved by an effective annealing. At the outset, therefore, a sufficiently high grade of steel should be selected to permit of thorough final annealing.

Friction-driven Bench Drill.

We illustrate herewith a friction-driven bench drill press which, though similar to one illustrated in our issue of July 10th by the same makers, differs in the arrangement of the feed lever, in the table, and in having under the friction disk a cam and attached lever by which this disk is raised to or lowered from contact with the wheel on the horizontal shaft, and the spindle thus started or stopped, making the usual countershaft and belt-shifting arrangements unnecessary.

The machine is intended for holes from the smallest up to $\frac{5}{16}$ inch, and will run these small drills from 800 to 2,000 revolutions. It is made by the Stover Novelty Works, Freeport, Ill.

Machinery and Labor.

Under the above heading we find an article in *Engineering*, of London, which though the subject is discussed from the English standpoint, of course, and refers to English history, yet applies equally well here, and constitutes a very good answer to the charge that machinery is oppressive. The article is as follows:

The nineteenth century man has good reason to be proud of himself, for he has wrought a greater change in the material and social aspects of the world than ever was seen in a thousand years before. It is true that there have been civilizations before his—some of them very splendid—but they were local and parochial compared with that which is now rapidly enveloping the globe. Even the achievements of the Roman Empire, extending over long centuries, did not equal those within the memory of living men. The past civilizations rested on two bases—intellect and military—sometimes one and sometimes the other predominating. These sufficed for creating great cities and communities, for evolving systems of law, and for organizing and controlling armies. But they did little towards freeing man from the curse of living by the sweat of his brow. Human muscles were nearly the sole source of mechanical power. The trireme was rowed by slaves, the mill was turned by women, editions of books were produced by the pen, and all manufactures were the result of heavy toil. It was only by enslaving whole nations that the refinement and luxury of Roman society was rendered possible. By skillful organization, and, above all, by the stern repression of wars and feuds, the labor of Europe was turned to the best account, and so civilization prospered. Its limit, however, was marked by the amount of work a man could do in a day. But by the invention of the steam engine, this limit was swept away, and humanity was freed from the heaviest part of its burden of toil. No longer does the slave tug at the oar, the miner carry up the ore on his back, or the traveler tramp wearily from dawn to dark. But not only did the steam engine undertake the hard work of the world, but it begot machinery that rivals the best handicraft in skill, and exceeds it a thousandfold in production; rendering one man able to undertake the work of many. It is this relaxation from hard manual toil, and the ability to produce more than is needed to maintain life, that lies at the root of that wonderful development of our times.

A period of change always brings suffering to some, even if the general effect be one of great improvement. In the rearrangement of social conditions some of the old parts do not fit into the new scheme, and are flung out, or else need to be greatly altered before they can be utilized. At times during this century the changing conditions have caused immense suffering, which found expression in anti-machinery riots, Chartism, and other popular movements, and now some of these are being revived in a new form. In an introductory address, delivered by Mr. John Inglis to the Institution of Engineers and Shipbuilders in Scotland last Tuesday, there was a reference to a Hyde Park orator, who spoke of Labor as crucified between two thieves—Capital and Machinery. Little must the orator have known of the history of labor to refer to its present condition, with its powerful trade unions and an Eight-hours Bill looming in the near future, as crucifixion. Probably, however, as Mr. Inglis suggests, he was more intent upon using a sounding figure of speech than of finding one that represented the truth, and that all he wished to enforce was that the misery of labor was embittered by the presence of capital and machinery.

There is, unfortunately, no doubt that labor is passing through a period of trial, and that the pressure upon it will increase as we get farther into winter. It is only natural that at such a time men should cast about to find the reason, and that those with untrained minds should seize upon the first that comes to hand, and repeat it until it becomes accepted by persons like themselves. The proposition, that if it required two men to do the work now accomplished by one, there would be a greater demand for labor, appears so charmingly simple when launched with rhetorical skill at a popular gathering, that it is pretty sure to find a good deal of acceptance, and be the means of leading people into economic error. The mob orator has an immense advantage over the man that discusses such a question

FRICTION DRIVEN BENCH DRILL.

scientifically, in that he demands no thought on the part of his audience. At a time like the present when many people are beginning to doubt the value of the greatest blessing—next to settled government—ever evolved by the human race, it is essential that those who are better informed should speak out, and we are glad to see that Mr. Inglis adopted the course we have persistently advocated of making his inaugural address the expression of his great experience and mature thought, instead of following the usual custom of giving a string of incomplete and unsatisfactory statistics.

He summed up the popularly alleged causes of the present slackness of demand for our wares, and of the abasement of ocean freights, under four heads, viz., monometallism, labor disturbances, the private ownership of land and minerals, and overproduction. The first three he dismissed very briefly. He has no faith in bimetallism; he deplores industrial wars, but points out that, at any rate, they are an antidote to overproduction. As for land tenure, he believes that the usages connected with the occupation of land have yet to be completely adapted to the new environment of which modern mechanical appliances are mainly the cause, and that this adaptation, like all radical changes, will probably continue to be attended by much suffering to individuals. To the fourth alleged cause—overproduction—he devotes greater space. In this relation, he says: "The truth about the matter I believe to be that the condition of things, which we agree to call over-production, or depression of trade, is not primarily due to machinery, but, in a great measure, to the reckless borrowing by impecunious States, communities and associations, encouraged by the imprudence of financiers, and the credulity of the public as to the powers of governments and other debtors to fulfill their obligations. The abnormal and unwarranted demand for goods from those put in easy possession of borrowed funds is rapidly met by the setting in motion of modern machinery—itself partly brought into existence by the necessity temporarily created. High prices become the rule, until the inevitable glut takes place, when there follows the revulsion to prices that are unremunerative. The fall in values is, perhaps, increased in rapidity by machinery, but the unwholesome stimulus is not immediately traceable to mechanical appliances." This explanation is more satisfactory to the capitalist than to the laborer; for the latter seldom reaps such a harvest during the good times as will carry him comfortably over the periods of depression. It is undoubtedly true that machinery does displace manual labor very often, and that it does not always produce such a lowering in price that the increased demand reinstates the men who have been superseded. Mr. Inglis finds from the census returns, by Messrs. Booth, Hobson, and Marshall, that while the output of textile goods has enormously increased, the proportion of labor employed in their production has continuously diminished. Again, while the rural population has declined but little, the number of persons engaged in agricultural labor has largely decreased, and this falling off began long before the comparatively recent fall in rents, and what is known as the decay of agriculture in this country. What has become of the persons that would, had the strict ratio been maintained, have followed these pursuits? Evidently they have turned to others, either old or new. Commercial pursuits, shopkeeping, transport, and other industries show an increase beyond their due proportions; shipbuilding afforded employment to 40 per cent. more persons in 1891 than 1881; the making of machinery and tools required an increase of 28 per cent. during the decade; those engaged in road traffic and in the industries connected with it show an increase; coal miners have grown in numbers 35 per cent. in 10 years, while the output has only augmented 20 per cent. Of those released from manual labor, many have betaken themselves to professions. Clergymen, lawyers, doctors, teachers, painters, actors, and musicians are far more numerous, proportionately, than they were, and their pleasant lives are all due to machinery.

Indeed, were it not for machinery many of the inhabitants of this kingdom would not exist. The population of England at the Norman Conquest was about 2,000,000; in 500 years it had scarcely doubled. The conditions of life when muscle was the sole motive power, were too hard for all but the exceptionally strong. Prof. J. W. Draper has given us a picture of existence in the middle ages. "The houses were of wood, daubed with clay, and thatched with straw and reeds. They had no windows, and, until the invention of the saw-mill, very few had wooden floors. The luxury of a carpet was unknown; some straw scattered in the room supplied its place. There were no chimneys; the smoke of the ill-fed, cheerless fire escaped through a hole in the roof. . . The bed was usually a bag of straw, a wooden log served as the pillow." Æneas Sylvius, who afterwards became Pope Pius II., has left an account of a journey he made to the British Isles in 1430. He describes the houses of the peasantry as constructed of stones put together without mortar; the roofs were of turf, a stiffened bull's hide served for the door. The food consisted of coarse vegetable products. In some places they were unacquainted with bread. Crucified labor had not then even the poor consolation of having machinery and capital to share its woes.

The outcry against machinery is, when investigated, found to be directed against its increase, rather than its existence. A proposal for its abolition would raise a torrent of protest. For instance, the veriest Tower Hill demonstrator would be aghast at the railways being put out of use. He knows that it would mean immediate starvation. The fitter does not desire to do the old hard work of hammer and chisel, now better executed by the planing machine. The shipbuilder would be indignant if the ironworker proposed to destroy the converter and the Siemens-Martin furnace, and to return to puddling, because he knows that increased price of plates would mean lessened demand for shipping. Probably every one would be satisfied if the additions of the last four or five years could be done away with. We all like to gather fruit, but we object to the labor of planting trees for posterity. It is the constant change of conditions that presses so heavily on the present generation, and particularly on the working classes. They have to be ever adapting themselves to an altered environment, and the process is very trying to the least apt of them. Unfortunately, this seems to be a law of existence. Were the population absolutely stationary, things might be different. But it always increases, in this country at least; and the moment life becomes easy and pleasant the rate of growth augments to upset the arrangement. What the end will be no one can tell, but at least we know that all great improvements have come out of suffering. In the meantime the best we can do is to try and ease the tight places in the great social machine, and not to enter into rash experiments with undue haste. We see how much individual pain comes from the slow unfolding that occurs naturally, and we may be sure that even were there all the good in the radical schemes of socialists and collectivists that their authors believe, their sudden introduction would be attended with disaster and death to immense numbers. In spite of the misery and destitution that exist, it is impossible to deny that the conditions of living have improved in a marvellous manner during the last fifty years; that the nation is better fed and clothed, and has far more social and intellectual enjoyments. It may be that we have not followed the best or the wisest course, but it is certain that to retrace our steps would carry us to privations and sufferings of which we can form no adequate conception.

The Sizes of Stubs' Steel Wire Gauge.

We have had several inquiries for the decimal equivalents of the sizes of the "Stubs Steel Wire Gauge" referred to in our issue of October 11th, under the title of "A Sample Wire Gauge Muddle." We have therefore written to Peter Stubs, Warrington, England, for the information, and have received a table from which the sizes given below are taken, and which are, therefore, authentic. At the same time we cannot refrain from repeating our oft-repeated injunction to discontinue the use of all existing wire gauges, and refer to all wire by its actual diameter in decimal parts of an inch.

STUBS' STEEL WIRE GAUGE.

Z	.413	Q	.332	H	.266
Y	.404	P	.323	G	.261
X	.397	O	.316	F	.257
W	.386	N	.302	E	.250
V	.377	M	.295	D	.246
U	.368	L	.290	C	.242
T	.358	K	.281	B	.238
S	.348	J	.277	A	.234
R	.339	I	.272		

Nos.		Nos		Nos.		Nos.	
1	.227	21	.157	41	.095	61	.038
2	.219	22	.155	42	.092	62	.037
3	.212	23	.153	43	.088	63	.036
4	.207	24	.151	44	.085	64	.035
5	.204	25	.148	45	.081	65	.033
6	.201	26	.146	46	.079	66	.032
7	.199	27	.143	47	.077	67	.031
8	.197	28	.139	48	.075	68	.030
9	.194	29	.134	49	.072	69	.029
10	.191	30	.127	50	.069	70	.027
11	.188	31	.120	51	.066	71	.026
12	.185	32	.115	52	.033	72	.024
13	.182	33	.112	53	.058	73	.023
14	.180	34	.110	54	.055	74	.022
15	.178	35	.108	55	.050	75	.020
16	.175	36	.106	56	.045	76	.018
17	.172	37	.103	57	.042	77	.016
18	.168	38	.101	58	.041	78	.015
19	.164	39	.099	59	.040	79	.014
20	.161	40	.097	60	.039	80	.013

The Army Quartermaster, at West Point, seems to be rather hard to satisfy in the matter of road rollers. It seems that he recently received bids for a roller from American builders, but that none of their machines suited him, and he bought one of English make without receiving bids. His action was, however, overruled by Secretary Lamont, who ordered that bids be again advertised for.

At Creston, Iowa, a court recently decided that an employe of the C., B. & Q. R. R., who had been injured while in service, had no claim against the company for damages, because he had accepted relief from a relief fund or association maintained for the benefit of injured employes.

Geo. F. Meyer, a mechanical and civil engineer, who was employed by Ericsson for some time, and was latterly connected in an engineering capacity with the De La Vergne Refrigerating Co., of this city, died of diphtheria on the 25th ult.

MANUFACTURES

Joe Dorris will rebuild his recently-burned cotton ginnery at Elgin, Tex.

The manufacture of furniture may be established at Houston, Tex.

James W. Tate is interested in a proposed woodworking establishment at Burlington, N. C.

A $30,000 electric-light and street-railway system will probably be established at San Jacinto, Cal.

The Taft Company, of Hartford, Conn., has voted to increase its capital stock from $15,000 to $30,000.

The Textile Machine Company, of Philadelphia, will locate at Hudson, Mass., a plant to employ 150 hands.

The Winsted Yarn Co., Winsted, Conn., will build a two-story addition, 15x60 feet, and put in new machinery.

The South Norwalk and Norwalk (Conn.) Electric Company talks of locating its entire plant at Norwalk proper.

Comstock, Cheney & Co.'s ivory works at Ivoryton, Conn., are now running full time with an increased force.

A five-mile electric-railway system will probably be established at Selma, Kan. L. M. Erb, of Leavenworth, is interested.

The rolling-mills connected with the Collinsville (Conn.) axe works placed a night gang at work, Wednesday night.

The steel mill of the Bethlehem Iron Company resumed operations November 26th, giving employment to 1,000 hands.

Three new tinning machines were purchased, and will be placed in the new tinning house of the tin plate mill at Ellwood, Pa.

A building is being built in Skowhegan, Maine, which will be used by William Stevens as a manufactory for his patent force pump.

The National Electric Headlight Company received an order from the Alabama & Great Southern Road for three electric headlights.

The Schollhorn Co. has decided to remain in New Haven, Conn., and will probably enlarge its plant to accommodate its increasing business.

Business at the Baker Forge Works, Ellwood, Pa., is picking up. They expect quite an increase in business in December, and are making preparations for it.

The Erie (Pa.) Pail Factory Company will erect a plant 220x50 feet and two stories high, to cost $12,000. The plant will be ready for occupancy early in January.

At a recent stockholders' meeting of the Cushnoc Fiber Company, Augusta, Maine, it was voted to add another paper machine to the plant at a cost of $35,000. It will make manila paper.

The ground has been staked out for a large addition to the factory of the Traut & Hine Manufacturing Co., New Britain, Conn. It will be five stories high, 50x100 feet, built of brick.

The Jenney Electric Motor Company has now got its force up to eighty-five men, and is pressed with orders. The company has about abandoned the idea of leaving Indianapolis.

Another story is being added to the north annex of Cluett, Coon & Co.'s factory, Troy, N. Y. The new story, which will be used to increase the laundry facilities of the concern, will be 100x50 feet.

The Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, say in a recent letter to this office: "We have more men at work, and more orders on our books than ever before, and are running at night to catch up."

It has been decided to rebuild the burned part of the Bath Iron Works, at Bath, Maine, and the contract has been awarded. This action would seem to indicate that the idea of removing the plant has been abandoned.

A new mill for the manufacture of coarse yarns will probably be established at New Bedford, Mass. The capital stock of the company will be $100,000. The mill will be 300x150 feet and one story. Local capitalists are interested.

The Nonotuck Silk Company will put up a new mill for the enlargement of their finishing department at Florence, Mass., next spring, and have contracted with Brown & Bailey for 300,000 brick. The foundations are already in.

The Eagle Bicycle Manufacturing Co., Torrington, Conn., is running nights, thirteen hours, with the prospects of continuing. It has very large orders from Chicago and St. Louis, and orders from other places, for the 1895 wheel, which will assure it business for some time ahead.

The Commercial Knitting Mills, at Troy, N. Y., are running day and night to fill large orders. The increased capacity of the plant will necessitate placing another boiler in the mills. The two old boilers will be placed with the new one in a building which will be erected soon.

The Link-Belt Machinery Co., Chicago, report recent sales of their standard water tube safety boiler to the following parties: Carnegie Library, Braddock, Pa., 50 horse-power; Morgan Building, Buffalo, N. Y., 375 horse-power; North Chicago Street Railway Co., Chicago, 3,000 horse-power.

The syndicate that wanted to utilize the water power at Bangor, Me., for a pulp-mill has located at Sault Ste. Marie, on the Canadian side. It has bought a canal and received a grant of 3,000 acres of land from the Ontario government, and will build the largest pulp-mill in the world, at a cost of $1,600,000.

The Meyer Jonasson Co., of New York, has leased a building in Bridgeport, Conn., for three years. This company is one of the largest clock manufacturing establishments in the country, and expects to employ 300 hands. The building is to be fitted up with 150 machines, and supplied with the latest electrical appliances.

The Pejepscot Paper Co. have been building this season a large pulp mill at Pejepscot Mills, Maine, on the Androscoggin. It is nearly completed, and will be running before January 1st. Ground wood pulp will be manufactured, and the capacity of the plant will be 40 tons daily. F. C. Whitehouse, of Brunswick, is treasurer of the company.

The Portland Company, Portland, Maine, have been awarded the contract for machinery for the new steamship of the International Line. The Portland Company have shipped the second locomotive for the Wiscasset & Quebec Railroad, and are working on several freight cars for the company.

We have received from the Sulzer Vogt Machine Co., Louisville, Ky., a catalogue (standard size, 6"x9") of their ice and refrigerating machinery. In its general style and make-up the catalogue is a very attractive one, and it contains much interesting information respecting the machinery of which it treats, and incidentally gives a considerable amount of information of value to the engineer in a general way, so that it is an especially valuable catalogue.

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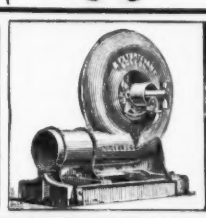

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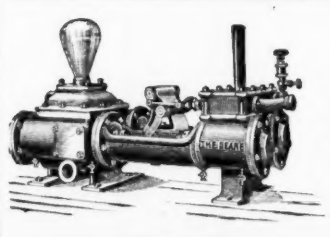

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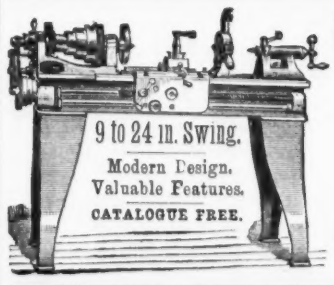

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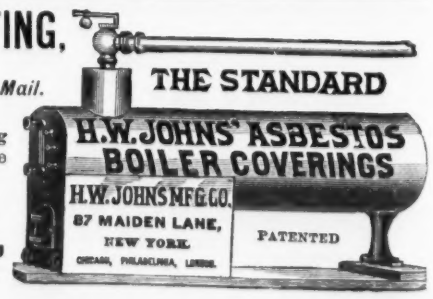

Machinists' Supplies and Iron.

NEW YORK, December 1, 1894.

Iron—American Pig—We quote standard brands, $12.25 to $12.50 for No. 1; $11 to $12 for No. 2. Southern brands, $11.50 to $12 for No. 1; $10.50 to $11.25 for No. 2; $10.25 to $10.75 for No. 3; $10.75 to $11 for No. 1 soft; $10.50 to $10.75 for No. 2 soft; and Foundry No. 4, $10 to $10.40.

Antimony—The market is steady, with lower prices. We quote L. X., 8¼c. to 8½c.; Cookson's, 8½c. to 8¾c.; Hallett's, 7.35c. to 7½c.; and U. S. French Star, 9¼c. to 9½c.

Lard Oil—Prime City we quote at 56c. to 57c.

Copper—The market is firmer, with a comparatively large demand. Producers are inclined to stand out for 9¾c. for Lake Copper, which buyers will not give at present. Sales have been made at 9.50c., and this price up to 9⅝c. are the quotation figures. Casting Copper is held at 9c. to 9¼c.

Lead—The market is inactive, and somewhat weaker in tone. The quotations are 3½c. to 3.15c. for New York delivery.

Spelter—The market is dull; very little business has been transacted. The quotations are 3.35c. to 3¾c. for New York delivery.

Tin—The downward tendency of prices continues, and reached 13.70c. at the beginning of the week, but later the quotations were 13.90c. to 13.95c.

✲WANTED✲

"Situation and Help" Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Situation wanted by competent mechanical draftsman. Address Box 93, Springfield, Mass.

Foundry foreman, American, 25 years' experience, 5 as foreman, wants situation. P. C., AM. MACH.

Young man, exp'd in design & costs of hydraulic tools & hoist'g mach'y, wants change. A. R. S., AMERICAN MACHINIST.

Wanted—Foremanship of machine shop. Thirteen years' experience, eight as foreman. Good refs. New York State pref'd. Age, 32. Box 61, AM. MACH.

Wanted—Foremanship of mach. shop; gas eng. shop pref'd, draftsman, good refs, age 35. A. M. S., AMERICAN MACHINIST

If you are manufacturers and want a good traveling salesman having experience, trade, and A1 refs. Address Want, care AMERICAN MACHINIST.

Wanted—A position on some R. R. by tech. grad. who has had 3 years' exp. in a locomotive repair shop, good refs. Box 51, AMERICAN MACHINIST.

Wanted—Sit. as assistant draftsman or machinist, willing to go anywhere; South preferred. Address C. B. Chynoueth, Houghton, Mich.

Sit. wanted in drafting-room, or as ass't superintendent, by a mech. eng'r & draftsman; 10 yrs' exp., 3 years on printing presses. Box 58. AM. MACH.

Foreman patternmaker wants "change." 20 yrs' exp.; best refs.; corres. solicited. Large shops. BOX 59, AMERICAN MACHINIST.

Young man with several years experience in drafting room and shop, with knowledge of modern machine shop methods, would like pos.; foreman of small shop pref'd. Work, AM. MACH.

Wanted—A young man competent to sell engines and boilers in a large machinery house in New York City. Address, stating qualifications and full particulars, Machinery House, AM. MACHINIST.

[*Continued on Page* 14]

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PROVIDENCE, R. I., U. S. A.

3000
VARIETIES FILES
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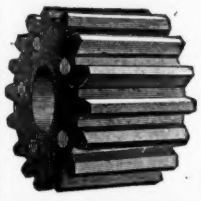
STRANGE, BUT TRUE!!
THE NEW PROCESS RAW HIDE GEARS
ASTONISH THE
MACHINERY WORLD.



They Outwear any Metal.
They require No Lubricant.
They are Noiseless and Clean.

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No.	Inch.	Price.
1	3-8	$ .40
2	1-2	.50
3	5-8	.60
4	3-4	.80
5	7-8	.90
6	1	.92
7	1 1-8	.92
8	1 1-4	.95
9	1 3-8	.95
10	1 1-2	.95
11	1 3-4	1.10
12	2	1.20
13	2 1-4	1.35
14	2 1-2	1.45
15	3	1.60
16	3 1-2	1.80
17	4	2.10
18	4 1-2	2.75
19	5	3.25
Full set of 19		$21.60
20 (ext.)	5 1-2	4.00
21 (ext.)	6	5.00

This Dog has a Very Heavy Boss, so that if the thread wears a Heavier Screw can be substituted.

When ordering, state as above, whether a full set or a set of 12, or small set of 8. Users of these dogs prefer them to any other make.

Le Count's Heavy Steel Dog.
With Steel Screws, Lathe Made and Hardened.

One Small Set of 8—by 1-4 inches to 20 inch, - - - $6.25
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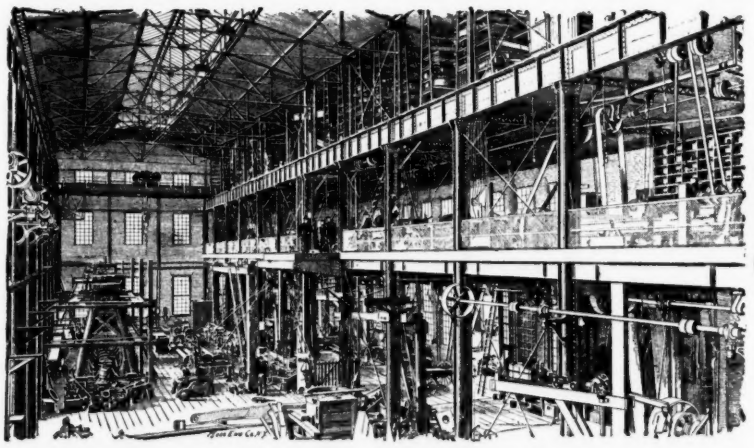

The above illustration is taken direct from a photograph and shows the interior of a Machine Shop designed and built by us for The Dry Dock Engine Co., at Detroit, Mich. The central portion, or Erecting Room, is 40 feet wide, with a gallery three stories high on one side, this gallery being 27 feet in width. The upper floor of the gallery is used for storing patterns, while the second floor is used for light machine work and the lower floor for heavy machine work—this lower floor being contr lled by jib cranes, which also swing out into the central portion, thus delivering material from the wings by the means of jib cranes and the traveling crane to any portion of the Erecting Room. The whole framework of the building is of Iron, with brick filling for the side walls.

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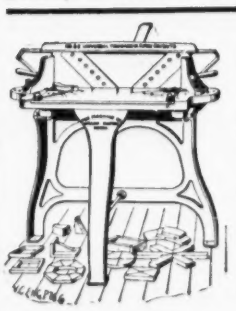

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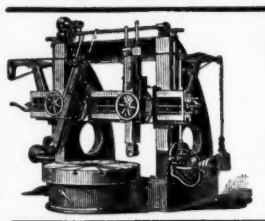

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PRESSES, DIES, TINNERS' TOOLS, SHEARS,
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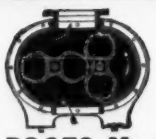

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Wanted—Superintendent for machine shop, manufacturing pulp and paper mill machinery. Iron and brass foundry connected. Located in a small New York town. BOX 60, AMERICAN MACHINIST.

Man (35) is open for engage't as mgr., asst. mgr., or supt. with mfr. of ornamental & structural iron. Grad. mech. eng'r, prac. mach., 2 yrs. in drafting room,& 4 yrs. mgr. of ornamental iron works in the South. Reason for change, wants to return North. Prefers New York or Boston. BOX 56, AM. MACH.

✣ MISCELLANEOUS WANTS ✣

Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cheap 2d hd lathes & planers. S.M.York,Clev'd,O.

Auto. Steam Flue Cleaners. Kelley Co., Erie, Pa.

Calipers & Gauges. F. A. Welles, Milwaukee, Wis.

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Wanted—To buy good second-hand tools. Box 83, AMERICAN MACHINIST.

Draftsmen's new knobbed combination triangles, stencils, etc. D. J. Kelsey, New Haven, Conn.

Model Locomotive Castings. Latest design. G. H. Olney, 163 Herkimer street, Brooklyn, N. Y.

Every mechanic should have a copy of "Pocket Primer of the Air Brake." Sent to any address for 50 cents. W. S. Rogers, Buffalo, N. Y.

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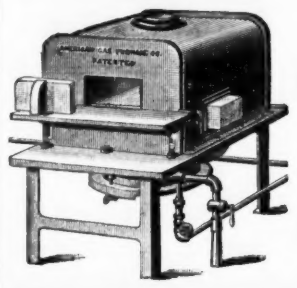

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16 in. x 4 ft. Planer.
24 " 4, 5 and 6 ft. Planer.
28 " 5 and 8 " "
30 " 5, 8 and 10 " "
60 " 20 " "
72 " 25 " "
9, 12, 16 24 and 26 in. Stroke Shaper.
10 in. Stroke Slotter.
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Plate Planer
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16 " 5, 6, 7 and 10 ft. Eng. "
18 " 6 7 and 8 " " "
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32 " 16 " " "
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18 in x 9 ft. D. W Pond.
20 in. x 6 ft. Bullard.
24 in. x 12 ft. Geo. Gage.
29 in. x 12 ft. Fifield.

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16 in. x 16 in. x 3 ft. Walter Bros.
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22 in. x 22 in. x 4 ft. L. W. Pond.
24 in. x 24 in. x 6 ft Whitcomb.
24 in. x 24 in. x 5 ft. Putnam.
28 in. x 28 in. x 7 ft. New Haven.

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Several Wood-working Machines.

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12 in. and 15 in. Lever and Screw Movement to Turret.
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120 in. Radial.
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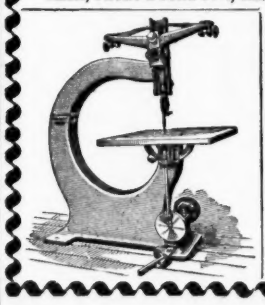

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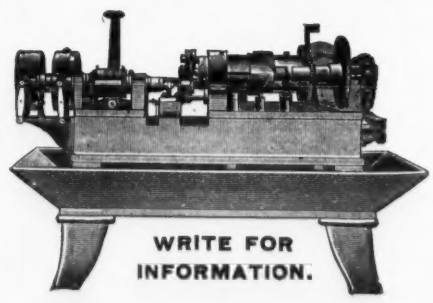

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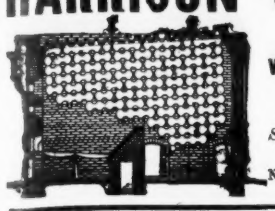

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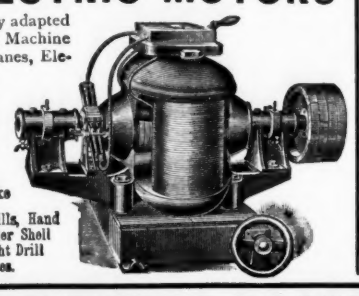

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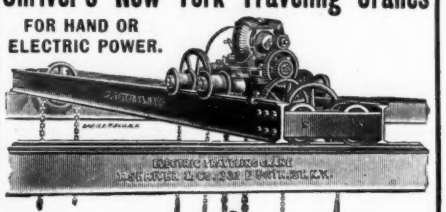

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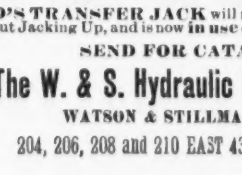

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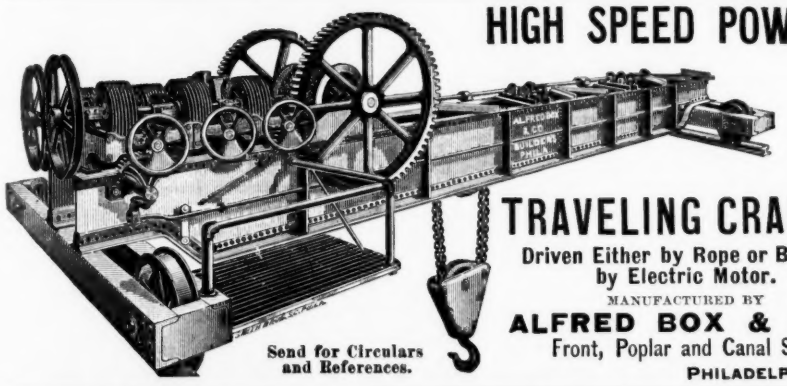

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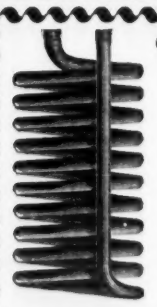

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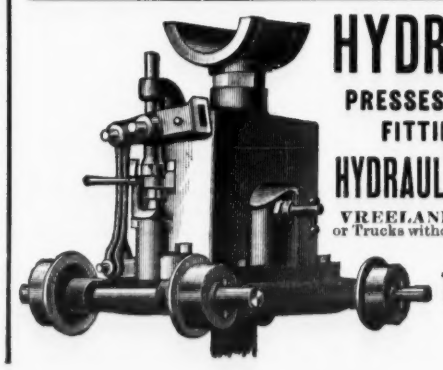

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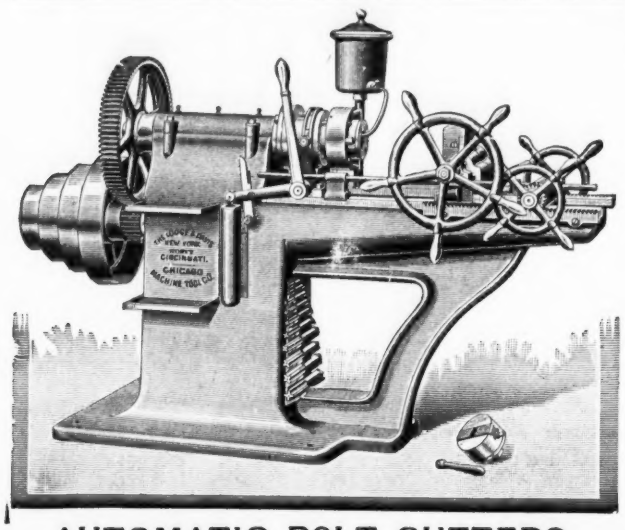

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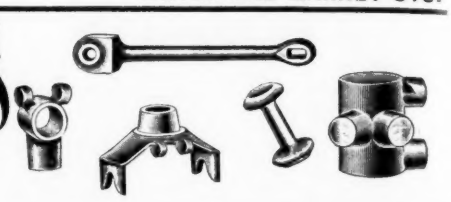

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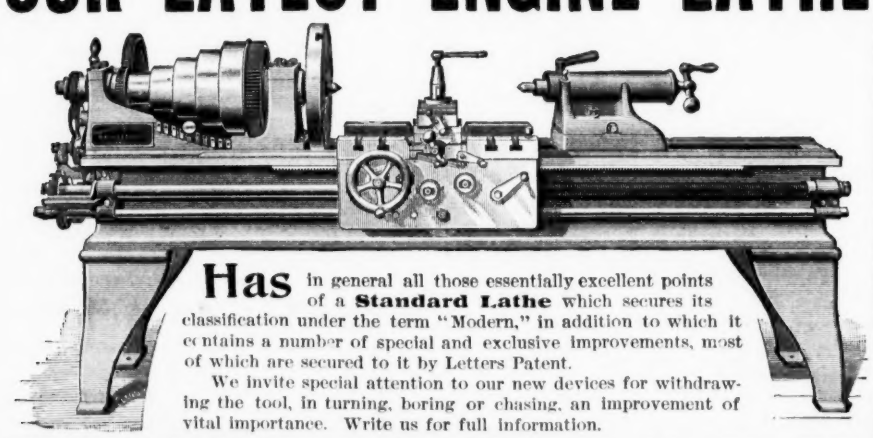

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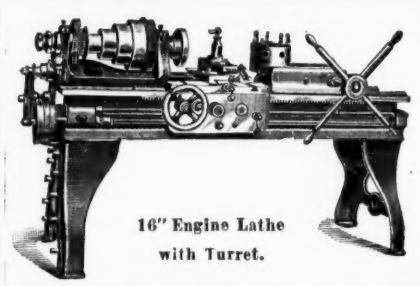

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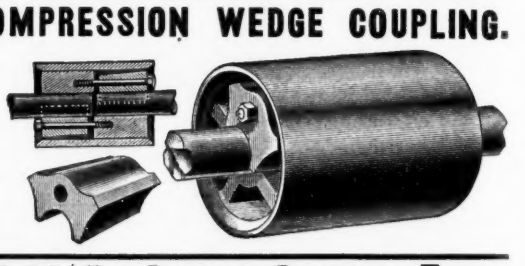

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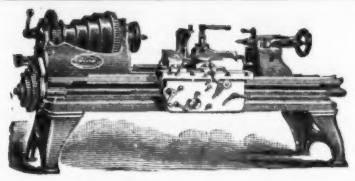

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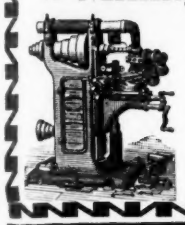

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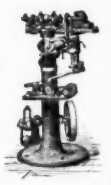

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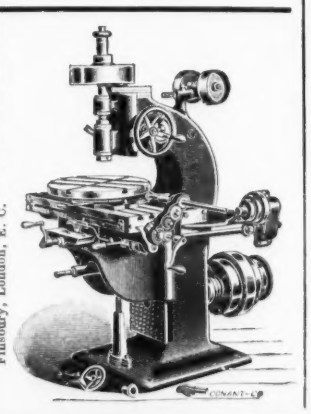

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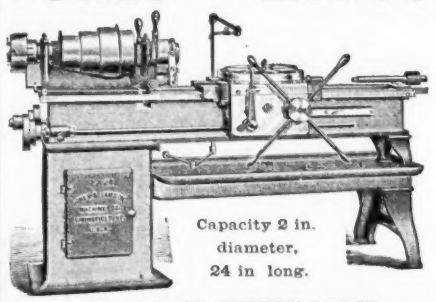

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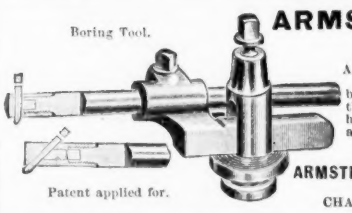

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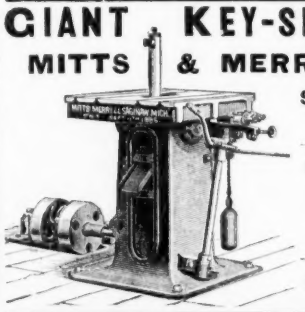

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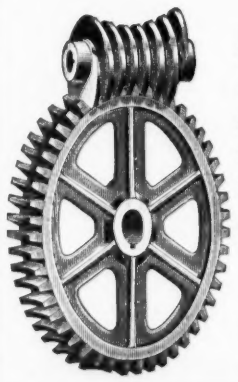

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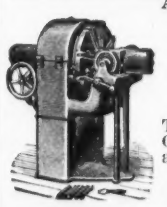

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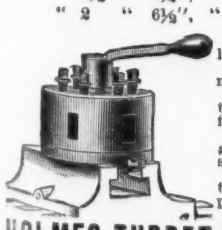

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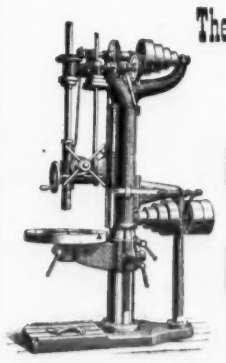

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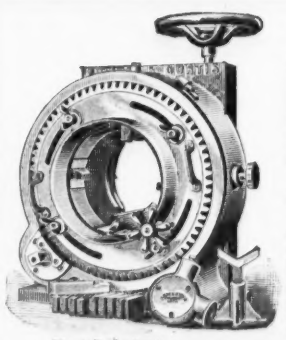

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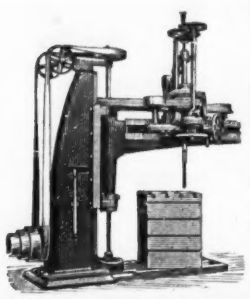

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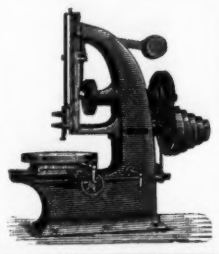

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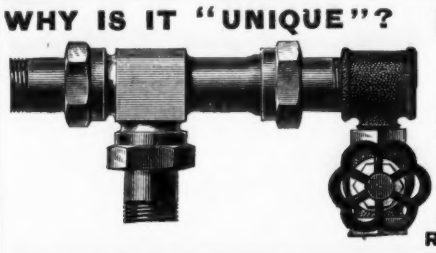

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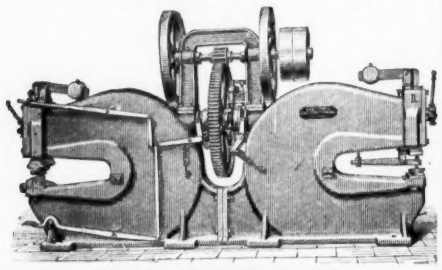

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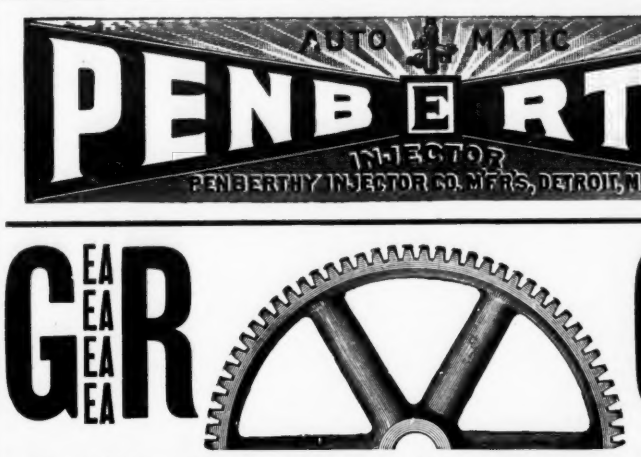

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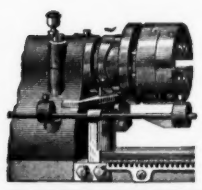

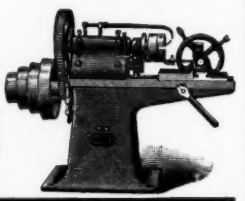

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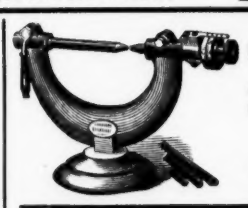

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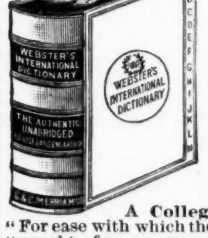

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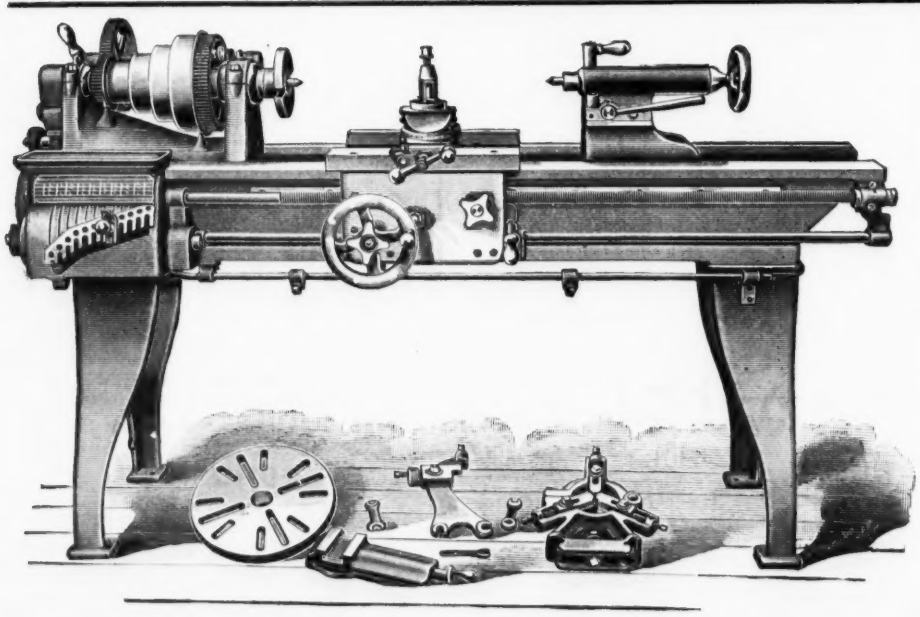

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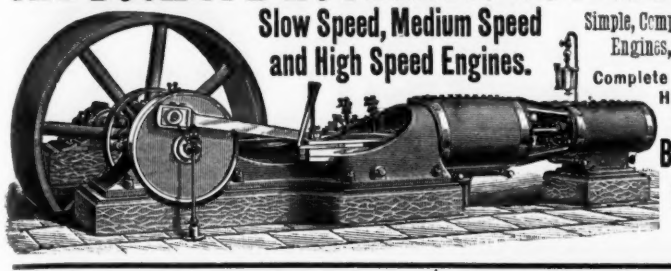

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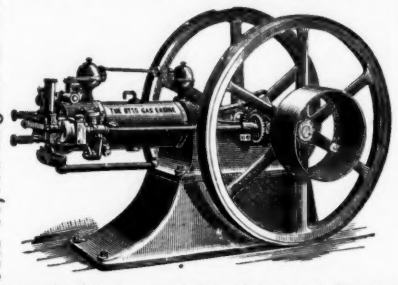

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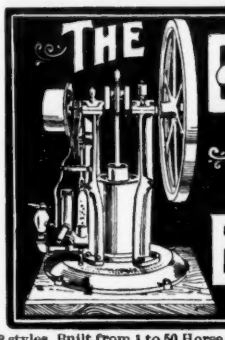

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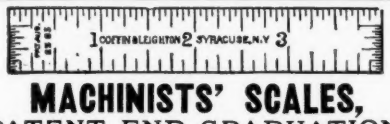

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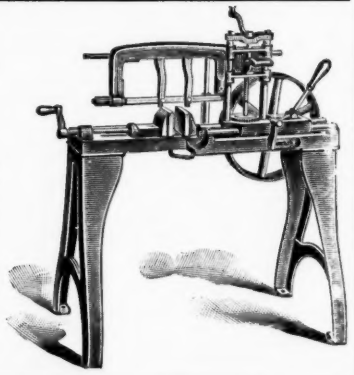

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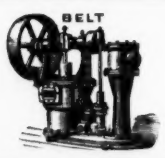

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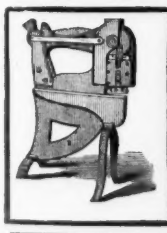

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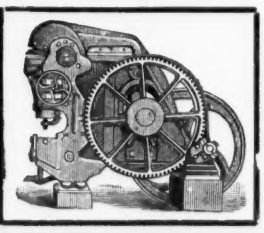

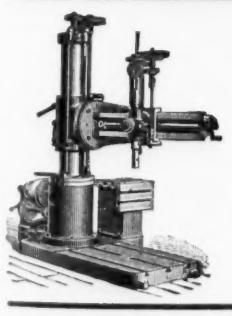

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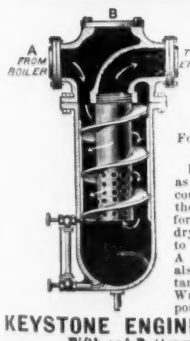

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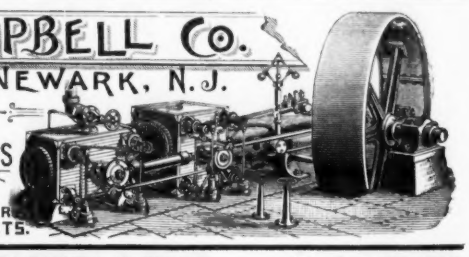

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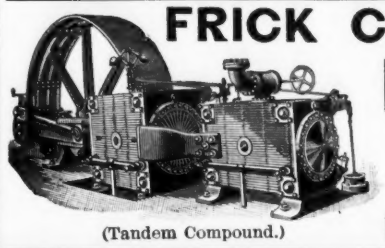

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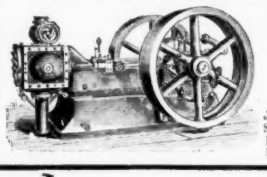

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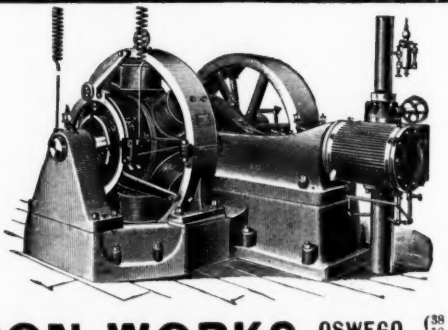

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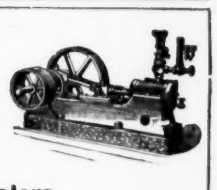

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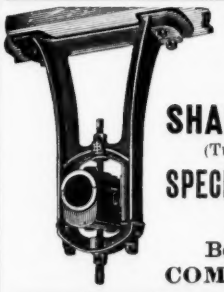

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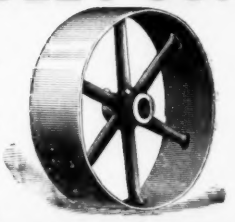

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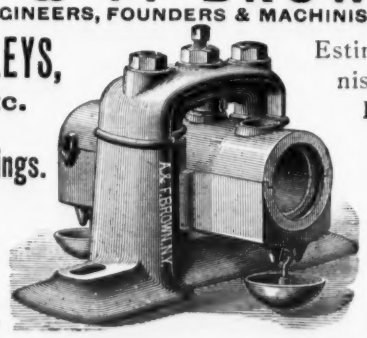

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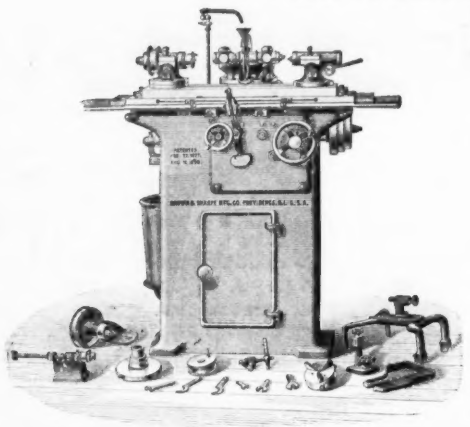

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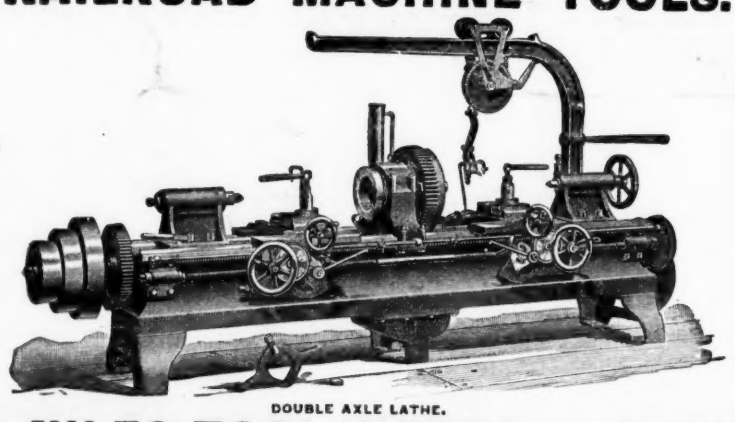

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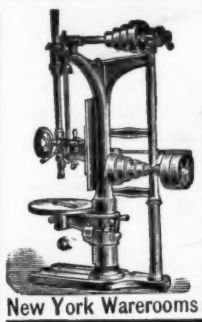

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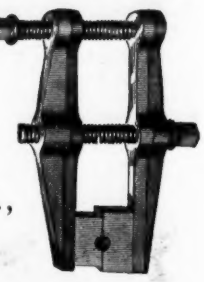

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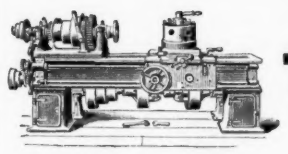

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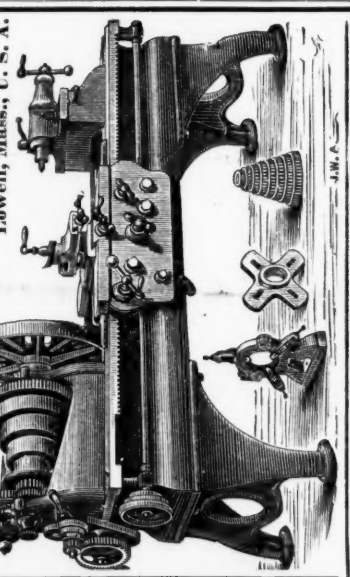

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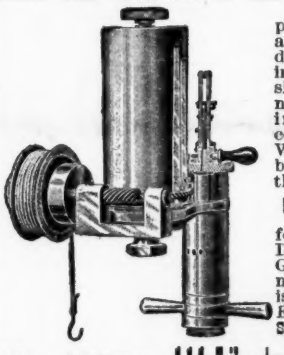

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